THE EFFECTS ON THE ENVIRONMENT OF THE 1965 BOLL WEEVIL DIAPAUSE CONTROL PROGRAM IN THE TEXAS HIGH PLAINS

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Plant Pest Control Division
Agricultural Research Service
United States Department of Agriculture
in Cooperation with the
Texas Department of Agriculture
Texas Department of Parks and Wildlife
and the
Texas Technological College

Gulfport, Mississippi

March 15, 1966

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TABLE OF CONTENTS

	Section No.
Summary	1
Boll Weevil Diapause Control Program (1965) - High Plains of Texas	2
A Comparison of the Effects of the 1964 and 1965 High Plains Boll Weevil Control Program on Population Trends of Non-target Arthropods	3
Effects of Aircraft Applications of Malathion on Fish and Aquatic Invertebrates	4
Effects on Quail, Migratory Birds, and Non-game Birds, of Aerial Applications of Malathion	5

INTRODUCTION

This is a collection of reports on continuing observations made by agencies interested in monitoring the side effects of the 1965 boll weevil diapause control program on the Texas High Plains. Agencies or institutions reporting are: Texas Parks and Wildlife Department, Texas Technological College, and Plant Pest Control Division, ARS, USDA.

An initial collection of reports by each of the above agencies was submitted in May 1965 to cover observations made on the first year's control program (1964). One final report is planned following the 1966 control program.

The 196[illegible] boll weevil diapause control program in [illegible] eighteen-county area of the High Plains of Texas was part of a continuing effort to prevent the westward spread of the insect through reduction of late boll weevil populations and reduction of the number of weevils entering hibernation. Technical malathion was applied at the rate of 16 ounces per acre. The first three applications were made at five- to seven-day intervals and the last four applications at ten- to fourteen-day intervals. Posttreatment survey showed that the potential overwintering weevil population was reduced by 99 percent.

Nontarget indicator organisms most severely affected were the lady beetle, *Hippodamia convergens* (Guer.); green lacewing, *Chrysopa* spp.; hooded beetles, *Notoxus* spp.; soft-winged flower beetles, *Collops* spp.; and scymnus beetles, *Scymnus* spp. Syrphid flies, family Syrphidae, and ichneumonid wasps, family Ichneumonidae, were two of the new indicator groups that were found to be highly susceptible to malathion. Spiders were not seriously depleted. Spring and summer populations of the indicator organisms did not seem to be adversely affected by the control program. Populations were larger in treated areas than in untreated plots, perhaps because of a decrease in the number of parasites and predators of the indicator species.

Two farm ponds were used as study sites to determine the effects of low-volume malathion applications to farmlands on caged test fish, resident fish populations, bottom sediment organisms, and zooplankton organisms. No adverse effects to these organisms were found during the duration of the study.

[illegible] bobwhite quail and caged quail exposed in the sprayed area were [illegible] by the malathion at the rates applied. Heavier concentrations of malathion [illegible] the birds quickly.

SUMMARY

The 1965 boll weevil diapause control program in an eight-county area of the High Plains of Texas was part of a continuing effort to prevent the westward spread of the insect through reduction of late boll weevil populations and reduction of the number of weevils entering hibernation. Technical malathion was applied at the rate of 16 ounces per acre. The first three applications were made at five- to seven-day intervals and the last four applications at ten- to fourteen-day intervals. Posttreatment survey showed that the potential overwintering weevil population was reduced by 99 percent.

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Two farm ponds were used as study sites to determine the effects of low-volume malathion applications to farmlands on caged test fish, resident fish populations, bottom sediment organisms, and zooplankton organisms. No adverse effects to these organisms were found during the duration of the study.

Native bobwhite quail and caged quail exposed in the sprayed area were not affected by the malathion at the rates applied. Heavier concentrations of malathion killed the birds quickly.

PPC, Gulfport, Mississippi
March 15, 1966

BOLL WEEVIL DIAPAUSE CONTROL PROGRAM
HIGH PLAINS OF TEXAS
1965

In the High Plains area of Texas the diapause control program was started in the fall of 1964 in an effort to prevent the spread of the boll weevil over the High Plains area and into the cotton-producing areas of New Mexico, Arizona, and California. This was a cooperative program between Plains Cotton Growers Association, the Texas Department of Agriculture, Texas A&M University, Entomology Research Division, and the Plant Pest Control Division. The objective of the program is to reduce the late boll weevil population, thereby reducing the number of weevils reaching diapause and going into hibernation.

The 1965 program began on September 7. Technical malathion was again used at the rate of 16 ounces per acre. Counties involved were Briscoe, Crosby, Dickens, Floyd, Garza, Hall, Kent, and Motley, with acreage reduced somewhat from the previous year. The first three applications of insecticide were made at five- to seven-day intervals, the objective being to break the reproductive cycle of the insect. The last four applications were at ten- to fourteen-day intervals, with the objective being the destruction of adult weevils which might survive the first three applications or which might have developed from eggs laid after the start of the program. The program was completed on November 17, 1965, with an aggregate of 1,512,548 acres being treated.

There were approximately 3,800 farmers within the zone, who cultivated about 5,400 cottonfields, comprising 249,000 acres. Only four farmers, controlling less than 150 acres of cotton, refused to cooperate.

Because of the vastness of the control zone, the area was divided into six units, each with a unit supervisor, airstrip supervisor, ground observers,

and the necessary number of spray aircraft. Also, mobile equipment was assigned to each unit, thereby making each unit an independent operation, which moved from one airstrip to another as the work progressed. Eighteen strategically located airstrips within the control zone were necessary and were used alternately throughout the program. The planes flew at an altitude of approximately 25 feet, covering a 100-foot swath. All employees were furnished two-way radios to tie the control zone into a complete radio network. Field checks showed that the 1965 program reduced the potential overwintering boll weevil population in the control zone by 99 percent.

Organizational and educational meetings were held throughout the control area with cooperating agencies and interested parties prior to the beginning of the program. All types of communication media were used to inform the public and farmowners of the treatment program. The Texas Department of Agriculture contacted all of the farmers in the area and obtained signed permits for spray applications from all except the four mentioned above.

Prior to the commencement of the program, a two-day training meeting was conducted for all cooperator personnel assigned to the program. A special session of this meeting was reserved for discussion concerning safety, including vehicular and pesticide, and also safe working practices. PPC airstrip supervisors were charged with the responsibility of insuring that contractor personnel and PPC personnel utilized soap, water, and towels when necessary. These items were available and required not only at the airstrips, but in all vehicles assigned to the program. It was also the responsibility of the airstrip supervisor to see that no automobiles were parked in the vicinity of the loading site on the airstrip. Local doctors were notified of the nature of the insecticide being used, its symptoms and antidotes. All insecticide was stored under lock and key, and all empty drums were sold to

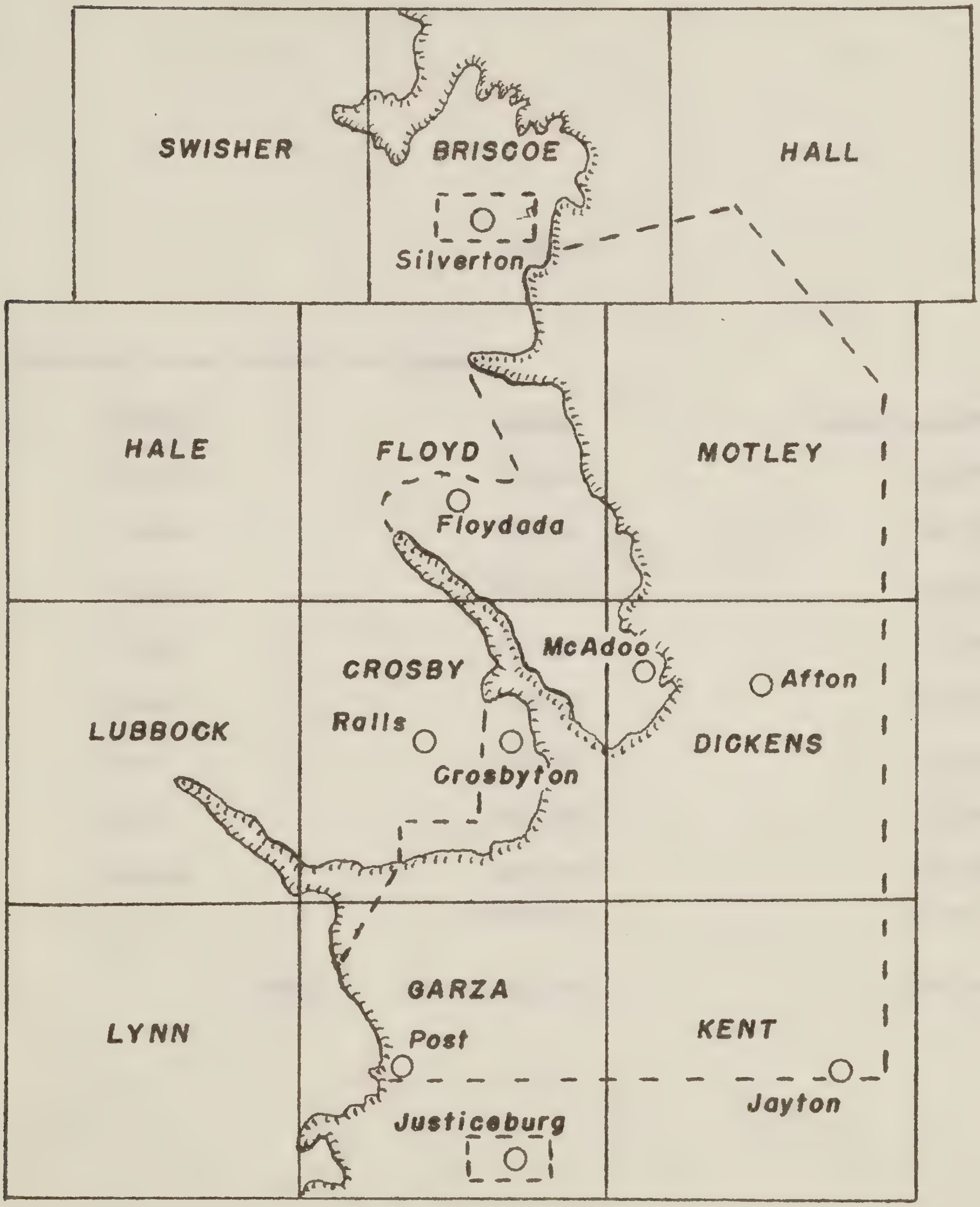
cooperage firms equipped with decontamination furnaces. Personnel of the Department of Entomology, Texas A&M University, supervised the removal of bee colonies from the area.

Only two minor incidents occurred during the program with reference to the use of malathion. On two separate occasions, workers were repairing hose on the underside of the spray plane when connections broke, spilling malathion into their faces and the upper parts of their bodies. There were no ill effects or loss of time. One of the workers experienced a slight rash around the waist in the vicinity of the belt line. No medical attention was required for either of the employees. There was one accident with one of the observation planes. The contractor's representative and the PPC field supervisor were in the plane at the time. The accident was caused by the nose wheel of the plane giving away after hitting a hole in the runway. Both men required medical treatment.

Attachments:
Map - Limits of control zone, 1965
Table I - Acres treated

San Antonio, Texas
February 23, 1966

1965 DIAPAUSE BOLL WEEVIL CONTROL PROGRAM
ON THE TEXAS HIGH PLAINS



— — — Limits of Control Zone, 1965.

TABLE I

Aggregate acres treated per county:

County	Acres	Gallons Insecticide
Briscoe	83,212	10,401
Crosby	304,765	38,095
Dickens	368,355	46,044
Floyd	222,913	27,864
Garza	98,833	12,354
Hall	89,729	11,216
Kent	141,644	17,705
Motley	203,097	25,387
Total	1,512,548	189,066

A [illegible] OF THE EFFECT OF THE 1964 AND 1965

[illegible] PLAINS BOLL WEEVIL CONTROL PROGRAM ON

[illegible] TRENDS OF NON-TARGET [illegible]

Ellis W. Huddleston
Donald Ashdown
Donald C. Herzog

REPORTS ON AGRICULTURAL INDUSTRY

A COMPARISON OF THE EFFECTS OF THE 1964 AND 1965 HIGH PLAINS BOLL WEEVIL CONTROL PROGRAM ON POPULATION TRENDS OF NON-TARGET ARTHROPODS

Ellis W. Huddleston
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ENTOMOLOGY REPORTS NUMBER 66-1

SCHOOL OF AGRICULTURE ● TEXAS TECHNOLOGICAL COLLEGE, LUBBOCK

A COMPARISON OF THE EFFECTS OF THE 1964 AND 1965 HIGH PLAINS BOLL WEEVIL CONTROL PROGRAM ON POPULATION TRENDS OF NON-TARGET ARTHROPODS

Ellis W. Huddleston, Donald Ashdown, and Donald C. Herzog

SUMMARY

The High Plains Boll Weevil Control Program, initiated in the fall of 1964, was continued in the fall of 1965. Direct effects of the use of ULV Malathion on non-target arthropods were studies during and immediately after the conclusion of the 1964 program. In addition to an evaluation of the direct effects of the 1965 control operations, population trends of the indicator arthropods were followed throughout the 1965 growing season to determine the "carry-over" effects of the 1964 program of the preceeding fall.

The indicator organisms most severely affected were the lady beetle, *Hippodamia convergens* (Guer.); lace-winged flies, *Chrysopa* spp.; hooded beetles, *Notoxus* spp.; soft-winged flower beetles, *Collops* spp.; and scymnus beetles, *Scymnus* spp. of the new indicator groups added to the study in 1965, syrphid flies, family Syrphidae, order Diptera, and ichneumonid wasps, family Ichneumonidae, order Hymenoptera, were found to be highly susceptible to ULV Malathion. Spiders, also added in 1965, were not seriously depleted. As in 1964, the insects least affected were nabid bugs, *Nabid* spp.; big-eyed bugs, *Geocoris* spp.; and assassin bugs, family Reduviidae.

Spring and summer populations of the indicator organisms did not appear to be adversely affected. In fact, populations of several of the

indicator insects were larger in the control zone, treated in 1964, than outside the control zone where ULV Malathion had not been used.

This apparent "over-recovery" can best be explained on the basis of an upset in the "balance of nature" caused by decreasing the parasites and predators of the beneficial insects or limiting other parasites and predators of the hosts of the indicator insects studied.

The results of beginning the 1965 control program two or three weeks earlier than in 1964 may produce different results on the seasonal population trends in the spring and summer of 1966. Studies this spring and summer will be conducted to evaluate the "carry-over" effects of the 1965 program.

INTRODUCTION

The High Plains Boll Weevil Control Program, a cooperative federal, state, and local program, was initiated in the fall of 1964 to limit the westward spread of the cotton boll weevil, Anthonomus grandis (Boheman). Included in the control zone were the newly infested eastern edge of the High Plains of Texas and the adjoining western edge of the Red Rolling Plains. An escarpment or caprock, which is the boundary of the two areas, had been the western limits of distribution of the boll weevil for many years. The level, fertile High Plains, intensively cropped with irrigated cotton and grain sorghum, and the rolling, relatively infertile Red Rolling Plains, extensively cropped with small cotton fields interspersed between large areas of range land, form two distinctly different ecological zones. Although these zones share many of the same species of insects, other species are localized in one or the other of the zones; thus, population trends of a given insect vary greatly from one zone to the other.

The large-scale application of the insecticide in this control program was expected to have both immediate and long-range effects upon both the target insects and the non-target arthropods. Since the "balance of nature" is a precarious and dynamic balance in which change is the rule rather than the exception, any disruption of this balance might produce not only direct or primary effects, but also secondary and tertiary effects. Direct toxic action is readily apparent and relatively easy to measure; however, the secondary and tertiary effects on the food web of predaceous insects and spiders is superimposed on climatic effects, biological interactions, and cyclic population trends. These indirect effects must be measured within the framework of large experimental error or variation, thus making anything

but large differences impossible to detect and even more difficult to adequately interpret. Since all possible food sources and natural enemies of a single indicator species could not be sampled adequately with the time and funds available, and since the relative importance of each species is not well known, many assumptions had to be made in choosing species to be used as an index of the effects of this program on non-target insects.

The immediate effects of this program on non-target insects in both the treated and untreated areas above and below the caprock were investigated in the fall of 1964. These results were reported in the 1964 progress report. This present report is a continuation of the same study, and presents the results of the investigation of the effects of the 1964 program on the population trends of non-target insects in the 1965 season. In addition, the direct effects of the 1965 program are compared with those of the 1964 program.

MATERIALS AND METHODS

The same study areas used in 1964 were again sampled in 1965. These areas were: (1) the unsprayed area outside the treated area above the caprock; (2) the sprayed area above the caprock; (3) the sprayed area below the caprock; and (4) the unsprayed area outside the sprayed area below the caprock. In each study area, eight locations were selected so that cotton and non-cultivated land were adjacent. At each of the thirty-two locations, duplicate samples were taken from both the cotton fields and the non-cultivated land. The entire study area is located within twenty miles either side of a seventy mile line from north of Crosbyton to Snyder, Texas.

In 1964, samples were taken immediately preceeding the initiation of the program, and two and eight days after each of the four insecticide applications. During 1965, samples were taken at weekly intervals beginning in April in the non-cultivated land, and on July 19 in the cotton fields. Samples were taken three days after each of the seven applications of the 1965 program that began in early September. In 1964, 892 field samples were taken; the number of samples taken in 1965 was increased to over 2,100 separate samples.

The large variations in numbers of insects among locations demanded that a great number of locations be sampled. Since visual counting of individual cotton plants is extremely time-consuming and does not lend itself to a program of this nature, a gasoline-powered De-Vac vacuum insect net, developed by entomologists at the University of California, was used for collecting all samples. By using this device, large samples can be taken in a relatively short time. Each sample in 1964 consisted of the insects obtained from vacuum sampling 300 row-feet of cotton or from a 300-linear-foot transect on non-cultivated land. The sample size was doubled in 1965. The cone attachment with a ½ square-foot area was used on the vacuum net in all sampling. In both years, samples were kept in a cool, shaded place and taken to the laboratory each evening for separation.

The insects in the samples were separated from the vegetative material and other debris collected in the bags. This separation was accomplished by a modified Berlese funnel, made by soldering a 12-inch deep cone to the lower edge of an 8-gallon garbage can from which the bottom had been removed. Samples were concentrated in pint jars screwed into a ring lid soldered to

the bottom of the cone. A 40-watt light bulb was suspended in the can through a hole drilled in the lid of the can. The heat from this light drove the insects downward through the opening of the cone into the pint jar which was half-filled with denatured ethyl alcohol. To obtain the heat but to avoid light attraction, the light bulbs were painted black. Additional unpainted lights were placed below the collection jars to aid in attracting the insects from the funnel into the alcohol. A circle of ½-inch mesh hail screen was placed in the bottom of the garbage can at its juncture with the cone to avoid trash entering the collection jar; however, this was not completely effective. When the entire funnel was then inclined at a 25° angle, very clean samples resulted. The samples were kept in the separation device for 24 hours; then the jars were capped and labeled. The separated specimens of index species were counted and recorded as soon as possible.

Eight insects or insect groups known to be beneficial as predators of insects of cotton were chosen as indicator species. These included four taxonomic groups of beetles; the convergent lady beetle, *Hippodamia convergens*; the sycmnus beetles, *Scymnus* spp.; the soft-winged flower beetles, *Collops* spp.; and the hooded beetle, *Notoxus* spp. Also included were the three groups of the order Hemiptera: nabid bugs, *Nabis* spp.; big-eyed bugs, *Geocoris* spp.; and assassin bugs, family Reduviidae.

The other indicator chosen was the lace-winged fly, *Chrysopa* spp. of the order Neuroptera. Because of the importance of the larvae as predators, both the larvae and adults were analyzed separately.

In 1965 three additional arthropod orders were added to the 1964

indicator groups: a representative of the order Diptera, the syrphid flies, family Syrphidae; a representative of the order Hymenoptera, the ichneumonid wasps, family Ichneumonidae; and spiders, order Araneida. Also, separate counts of the adults and nymphs of assassin bugs, big-eyed bugs, and nabid bugs, and of the adults and larvae of the lady beetle were made.

DISCUSSION AND RESULTS

Control operations in the boll weevil program were initiated late in September, 1964, after all normally used cotton pest control programs had been terminated, and at a time too late for damaging populations of cotton pests to be important should they build up as a result of the reduction of beneficial insects. The major concern of "upset balance" was not with the immediate effect of the 1964 program, but with adverse carry-over effects that late-season spraying might have on the beneficial populations and the corresponding increase of cotton pests in 1965.

Results from the 1964 study showed that the indicator species most affected were the beetles -- lady beetles, *Scymnus* spp., hooded beetles, and soft-winged flower beetles -- and the lace-winged flies. Nabid bugs, big-eyed bugs, and assassin bugs appeared to be the least affected, although populations of all indicators were reduced as a result of the control operation.

The normal seasonal patterns of population trends for all of the indicators used in 1964, plus those added in the second year were studied in 1965. Generally, this pattern appeared to be a somewhat elongated, bell-shaped curve, skewed to the right or left, depending on the species and the eco-

logical zone. Populations of all insects appeared to remain very low until the cotton reached the four to six leaf stage, or until some pest species attained numbers sufficient to trigger an increase in beneficial population. Populations of beneficial insects began to decline rapidly in mid-September. This rapid late-season decline was apparent in both the 1964 and 1965 data.

Population trends of indicator insects and the effects of the High Plains Boll Weevil Control Program were found to be so variable from species to species that each has been discussed separately in this report.

Lady Beetle Adults: Above the caprock, lady beetles in the untreated area reached the seasonal peak early in July, with a subsequent, smaller peak at the end of July. Below the caprock, a small peak corresponding to the early July peak above the caprock was present; however, the seasonal high was reached on August 21. A third seasonal peak occurred both above and below the caprock at the time of the initiation of 1965 spray program in early September. The first spray resulted in virtually complete eradication of all lady beetles in the control zones, both above and below the caprock, (fig. 2, table 2). The normal seasonal decline in populations in the unsprayed check areas above and below the caprock accounts for a large portion of the apparent reduction in total populations by the control program.

Of major interest were the differences in populations between the control zone and the untreated area outside the control zone. A surprising and highly significant increase in lady beetle adults occurred in June and July, 1965, within the control zone above the caprock as compared to pop-

ulations in cotton fields outside the control zone above the caprock. The factors responsible for this increase have not been evaluated. It is possible that ULV applications created a disruption of the balance of nature resulting in fewer parasites and predators of the lady beetle, or the production of more pest insects, thus providing more food suitable and attractive to the lady beetles.

Early season populations of adult lady beetles below the caprock were generally similar to those above the caprock, but did not demonstrate this phenomenon of early season "over-recovery" or an increase in the previously treated area as compared to the untreated cotton fields.

Hooded Beetles: This early season "over-recovery", or excess number, can also be seen in the populations of hooded beetles above the caprock (figure 7). Here again the normal, late-season decline in beneficial insects that seemed to characterize this area, and the high toxicity of ULV malathion to coleopterous groups was apparent (table 7). The most significant example of "over-recovery" of a non-target insect is seen in the population trends of hooded beetles below the caprock. At no time during the season, until the beginning of control operation, was the population in the untreated area equal to the population in the zone which had been treated the previous year. This difference is very difficult to explain in that little is known of the life cycle and feeding habits of the hooded beetle. The possibility of a secondary or tertiary effect, not measured in this study, is further strengthened by the populations trends of this insect.

Soft-winged flower beetles: The populations of soft-winged flower beetles, although of a smaller magnitude, followed the same general trend as the lady beetles and hooded beetles, including the drastic reduction following the first spray application and early season "over-recovery" (table 9, figure 9).

Scymnus spp.: The population trends of scymnus beetles adds additional data to confirm the theory of "over-recovery" of beetles in the year following the large-scale use of ULV malathion (table 6, figure 6).

Lace-winged flies: As in 1964, lace-winged fly adult populations were severely and significantly reduced by the control program (table 4). Larvae were also quite susceptible to the insecticide (table 5, figure 5). In 1965 above the caprock, early-season populations of lace-winged flies were larger in the area treated in 1964 than in the area which had not been previously treated (figure 4).

Nabid bugs: The apparent early-season "over-recovery" occurred in the populations of nabid bugs in the area above the caprock. The occurrence of this phenomenon in a species not drastically affected during the 1964 control program seemed to add additional support to the idea that the control program disrupted the balance of nature by reducing the direct competitors; reducing parasites and predators of the particular insect; or indirectly increasing the food supply of the predaceous insect. The apparent increase of the populations near the end of the spray program is statistically significant and tends to confirm the same trend observed in 1964 (table 10, figure 10). Nabid populations below the caprock illustrate true oscillations of two populations both with significant increases and decreases occurring during the 1965 control program. Oscillations are

normal in an environment whether treated or untreated with insecticides.

Big-eyed bugs: Population trends of the big-eyed bug both above and below the caprock were quite similar to nabid bug population trends below the caprock (figure 8). Although some reduction occurred during 1964, and again in 1965, these reductions were not generally large, and are of much the same magnitude as those of the nabid bugs (table 8).

Assassin bugs: Assassin bugs appeared to follow the same general trend as closely related nabid bugs and big-eyed bugs (figure 11). Significant population changes appeared to be indirect effects of the environment and not direct effects of the application of insecticides (table 11).

Icheumon Wasps: The numbers of ichneumon wasps obtained by the sampling methods used in this study were not large; however, significant and uniform population reductions were apparent (table 12). Since this group of insects was not sampled in 1964, no comparison between years was possible.

Syrphid flies: Populations of syrphid flied were greatly reduced by the use of ULV malathion sprays (table 13). Although there were numerous smaller peaks throughout the year, seasonal peaks occurred in August (figure 13). The number of syrphid flies in each sample was very low. The vacuum insect net is probably less effective for this highly-mobile species than for some of the other indicator groups and syrphid fly numbers are probably lower than the populations of most of the other indicator organisms studied.

Spiders: Although there were some significant reductions in spider populations during and after the 1965 spray program, the over-all effect was one of slightly reduced populations and extreme variability in all

populations (table 14). Below the caprock, significant population reductions occurred after the first and second insecticide applications. The reduction after the third application was not significant; moreover, a highly significant increase in spiders occurred after the fourth application. Occurences of this nature lead to the assumption that these values are better explained on the basis of violent population oscillations than on the basis of effects of ULV Malathion. A real possibility exists that these population oscillations were secondary or tertiary effects of the spray program.

A highly significant reduction in the total numbers of all indicator species in cotton fields occurred following the first and second applications in both 1964 and 1965 (table 1). Following each of the subsequent applications large reductions in total indicator populations occurred, however, population numbers had reached levels that were too low and too variable for statistical significance. The percent reduction was smaller following the seventh application, probably due to the normal late seasonal decline in the unsprayed areas.

The t-test technique for statistical analysis of data was used in this study to compare indicator populations. Due to the experimental design necessitated by a large scale program of this nature, valid comparisons are best made by comparing the treated area with the untreated area within the same ecological zone on a given date. A series of comparisons was made using the data from the High Plains and another series of comparisons was made for the data from below the caprock. At this time, data from the non-cultivated

land has not been analyzed. If further analysis of the data shows that variances from area to area or date to date are homogeneous, or can be made to be homogeneous by transformation of the data; a more sophisticated analysis will be used.

Table 1. Percent reduction of all indicator species in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields		Non-cultivated Area	
		Above Caprock	Below Caprock	Above Caprock	Below Caprock
1	1964	89 xx	84 xx	49	7
	1965	71 xx	85 xx	+	66
2	1964	92 xx	76 xx	83	71
	1965	82 xx	85 xx	+	82
3	1964	---	---	---	---
	1965	85 xx	85 xx	88	
4	1964	87	69 xx	73	35
	1965	47	32	39	+
5	1964	---	---	---	---
	1965	65	58	48	73
6	1964	---	---	---	---
	1965	84 x	36	69	60
7	1964	---	---	---	---
	1965	38	41	37	68

--- not sampled in 1964.
+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

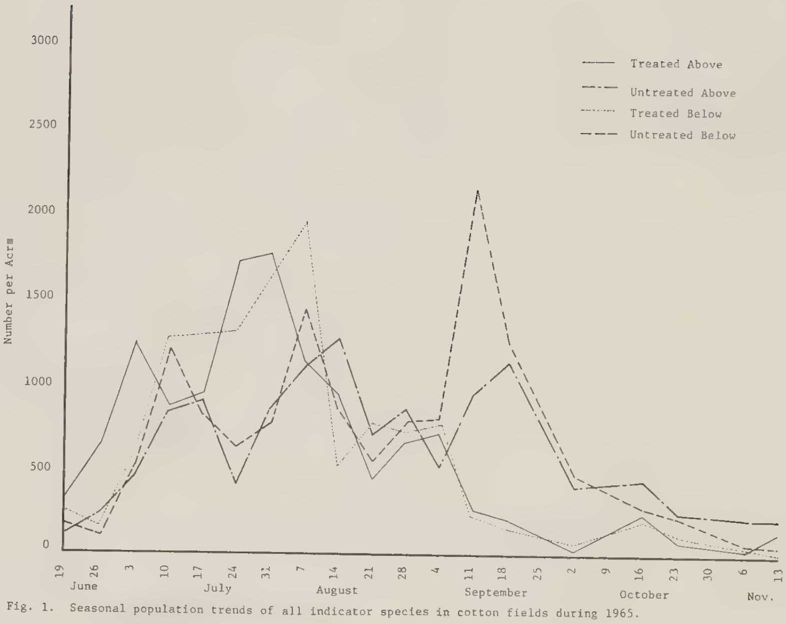

Fig. 1. Seasonal population trends of all indicator species in cotton fields during 1965.

Table 2. Percent reduction of lady beetle adults in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields		Non-cultivated Area	
		Above Caprock	Below Caprock	Above Caprock	Below Caprock
1	1964	100 x	85 xx	81	100
	1965	100 x	100 xx	100	100
2	1964	100	100	100	100
	1965	100 a	98 a	100	0
3	1964	---	---	---	---
	1965	100 x	100 xx	100	0
4	1964	100	100	100	*
	1965	100 xx	100 xx	100	100
5	1964	---	---	---	---
	1965	100 x	100 xx	100	100
6	1964	---	---	---	---
	1965	100	100	0	0
7	1964	---	---	---	---
	1965	100	100	0	0

--- not sampled in 1964.
+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

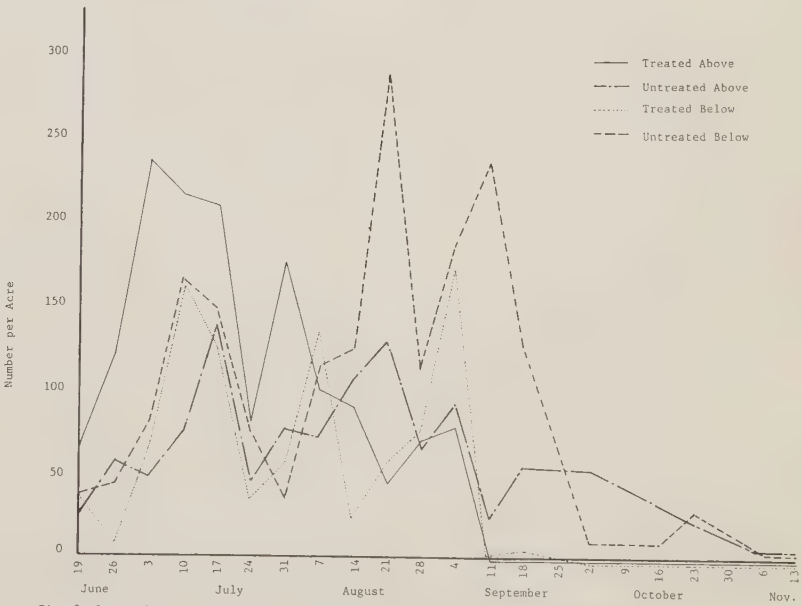

Fig. 2. Seasonal population trends of lady beetle adults in cotton fields during 1965.

Table 3. Percent reduction of lady beetle larvae in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields Above Caprock	Cotton Fields Below Caprock	Non-cultivated Area Above Caprock	Non-cultivated Area Below Caprock
1	1964	---	---	---	---
	1965	100	*	20	100
2	1964	---	---	---	---
	1965	100	*	100	*
3	1964	---	---	---	---
	1965	*	*	+	*
4	1964	---	---	---	---
	1965	100 x	*	0	*
5	1964	---	---	---	---
	1965	100 x	*	+	*
6	1964	---	---	---	---
	1965	80	*	100	*
7	1964	---	---	---	---
	1965	100 x	*	+	*

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

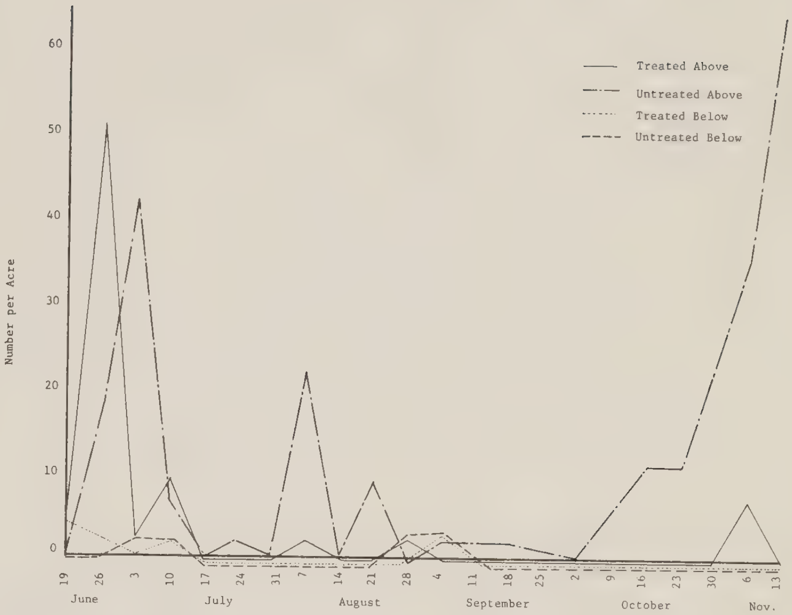

Fig. 3. Seasonal population trends of lady beetle larvae in cotton fields during 1965.

Table 4. Percent reduction of lace-winged adults in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields Above Caprock	Cotton Fields Below Caprock	Non-cultivated Area Above Caprock	Non-cultivated Area Below Caprock
1	1964	85 xx	100 x	99	100
	1965	100 x	99 xx	100	100
2	1964	100	100 x	56	100
	1965	100 x	86 xx	100	100
3	1964	---	---	---	---
	1965	94 x	100 xx	82	100
4	1964	100	97 xx	*	100
	1965	100 xx	100 x	71	100
5	1964	---	---	---	---
	1965	100 x	100 xx	0	100
6	1964	---	---	---	---
	1965	100	100 xx	0	100
7	1964	---	---	---	---
	1965	100 xx	78	100	*

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

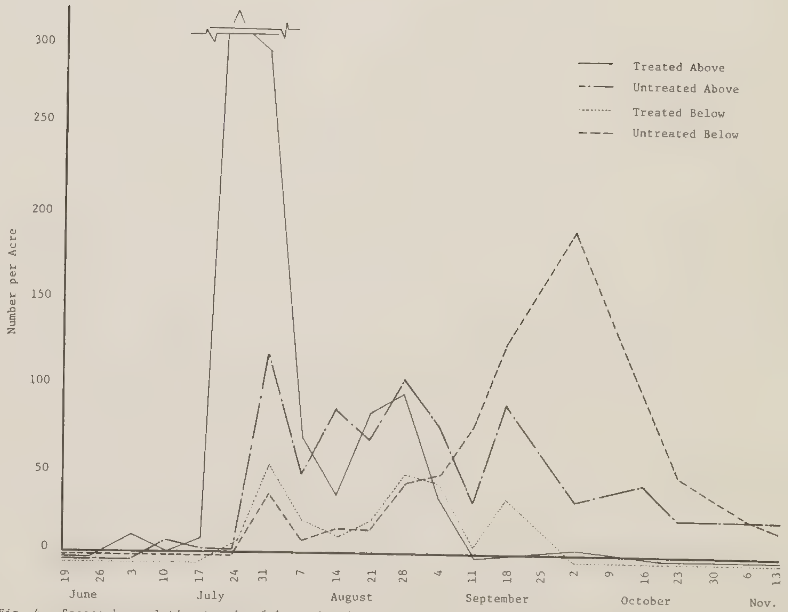

Fig. 4. Seasonal population trends of lace-winged adults in cotton fields during 1965.

Table 5. Percent reduction of lace-winged larvae in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields: Above Caprock	Cotton Fields: Below Caprock	Non-cultivated Area: Above Caprock	Non-cultivated Area: Below Caprock
1	1964	100	100	50	56
	1965	90 xx	80	59	0
2	1964	100	100	56	79
	1965	100	100 xx	0	100
3	1964	---	---	---	---
	1965	100	100	50	100
4	1964	100	100 x	*	100
	1965	100 x	50	100	0
5	1964	---	---	---	---
	1965	78	100	*	100
6	1964	---	---	---	---
	1965	*	100	*	100
7	1964	---	---	---	---
	1965	*	*	*	*

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

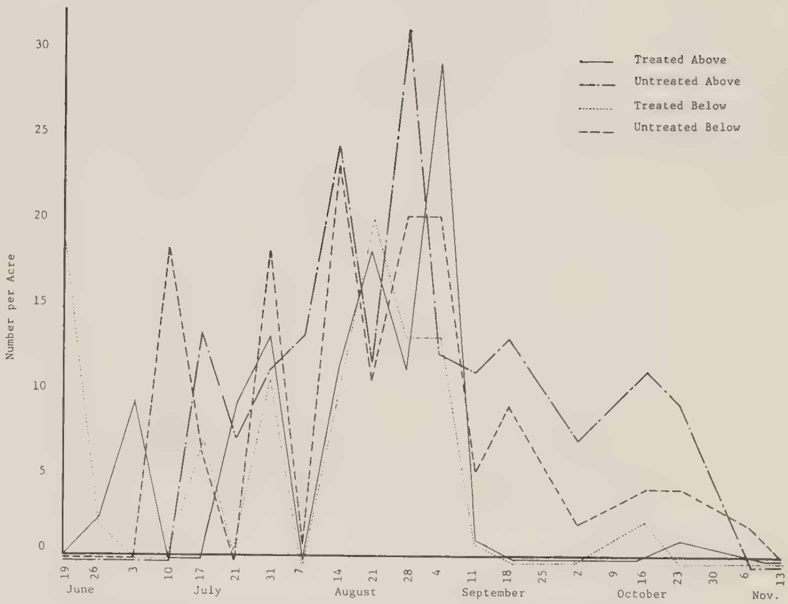

Fig. 5. Seasonal population trends of lace-winged larvae in cotton fields during 1965.

Table 6. Percent reduction of Scymnus spp. adults in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields: Above Caprock	Cotton Fields: Below Caprock	Non-cultivated Area: Above Caprock	Non-cultivated Area: Below Caprock
1	1964	100 xx	89 x	100	78
	1965	100 xx	99 xx	57	95
2	1964	100	87 x	82	85
	1965	100 x	99 xx	100	100
3	1964	---	---	---	---
	1965	100 xx	95 xx	100	100
4	1964	100	100	+	69
	1965	85	87	78	0
5	1964	---	---	---	---
	1965	100 x	100 xx	*	100
6	1964	---	---	---	---
	1965	0	100	*	100
7	1964	---	---	---	---
	1965	100	100	*	100

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

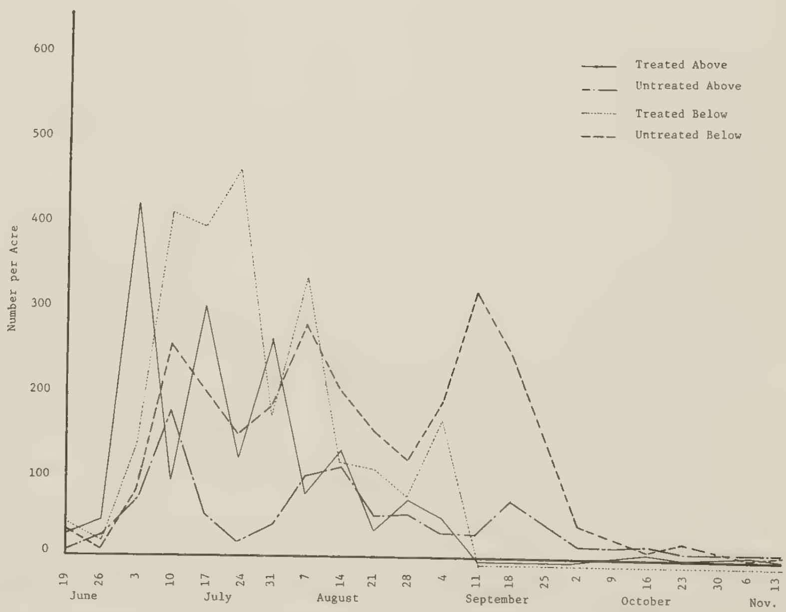

Fig. 6. Seasonal population trends of scymnus adults in cotton fields during 1965.

Table 7. Percent reduction of hooded beetle adults in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields Above Caprock	Cotton Fields Below Caprock	Non-cultivated Area Above Caprock	Non-cultivated Area Below Caprock
1	1964	100	100 xx	100	100
	1965	100	100 x	80	*
2	1964	100	100	*	+
	1965	100	71	100	+
3	1964	---	---	---	---
	1965	100 x	100 xx	+	100
4	1964	100	*	*	*
	1965	100	100 x	100	100
5	1964	---	---	---	---
	1965	100 xx	100 x	0	100
6	1964	---	---	---	---
	1965	100	*	*	*
7	1964	---	---	---	---
	1965	*	*	*	*

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

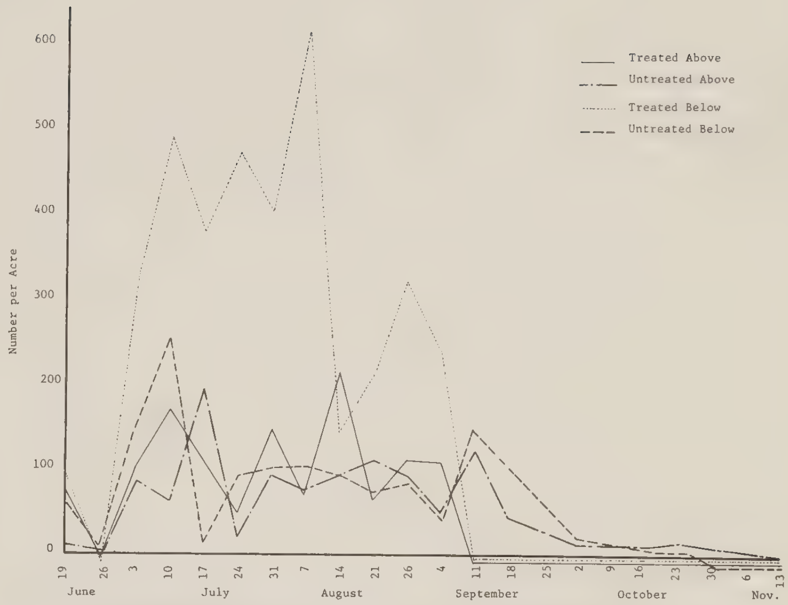

Fig. 7. Seasonal population trends of hooded beetles in cotton fields during 1965.

Table 8. Percent reduction of big-eyed bug adults and nymphs in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields Above Caprock	Cotton Fields Below Caprock	Non-cultivated Area Above Caprock	Non-cultivated Area Below Caprock
1	1964	+	100	+	+
	1965	71	50 x	+	75
2	1964	100	100	88	86
	1965	68 x	65	+	38
3	1964	---	---	---	---
	1965	100	50	65	71
4	1964	*	100	+	+
	1965	80 x	71	+	+
5	1964	---	---	---	---
	1965	100	100	63	+
6	1964	---	---	---	---
	1965	*	*	71	+
7	1964	---	---	---	---
	1965	*	*	100	+

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

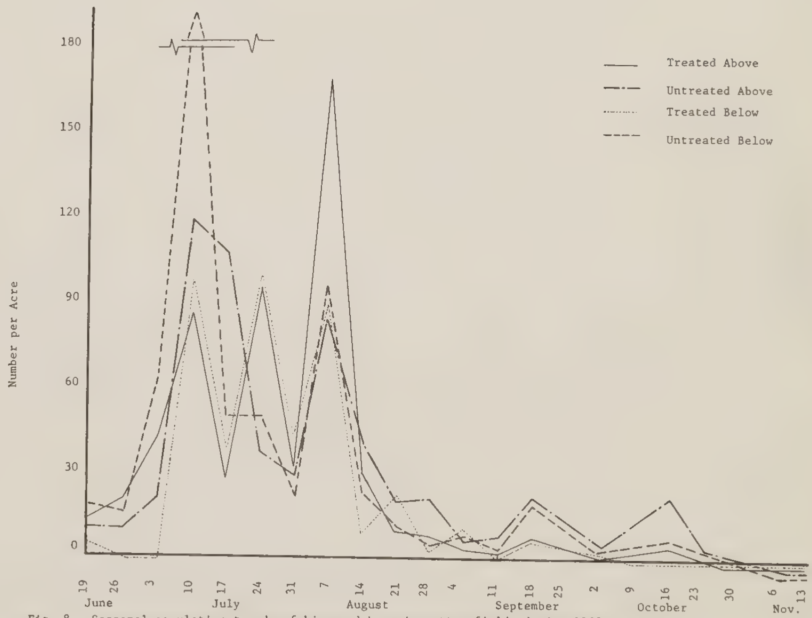

Fig. 8. Seasonal population trends of big-eyed bugs in cotton fields during 1965.

Table 9. Percent reduction of soft-winged flower beetle adults in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields: Above Caprock	Cotton Fields: Below Caprock	Non-cultivated Area: Above Caprock	Non-cultivated Area: Below Caprock
1	1964	33	0	41	0
	1965	88 x	100 xx	+	88
2	1964	100	100	0	100
	1965	100	100 x	15	100
3	1964	---	---	---	---
	1965	100 x	100	100	100
4	1964	*	+	100	*
	1965	78 xx	100	+	*
5	1964	---	---	---	---
	1965	*	100	0	*
6	1964	---	---	---	---
	1965	*	*	*	*
7	1964	---	---	---	---
	1965	*	*	*	*

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

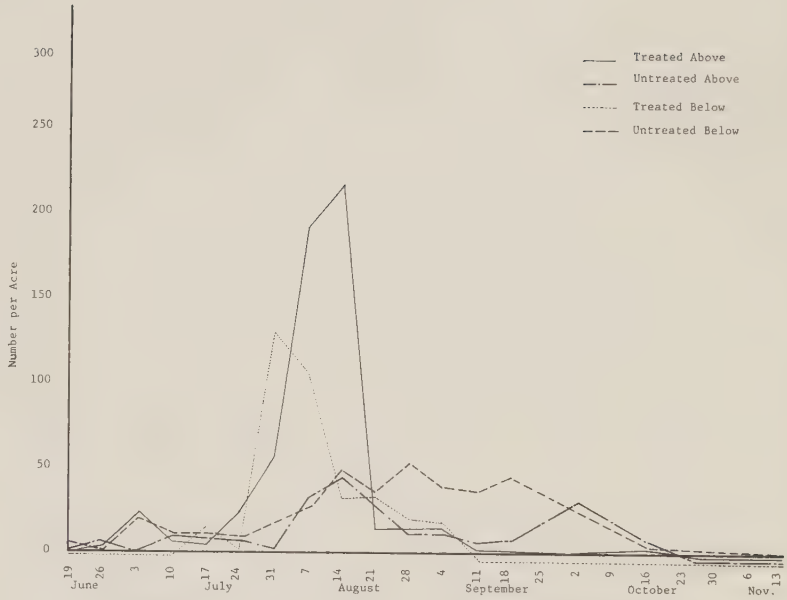

Fig. 9. Seasonal population trends of soft-winged flower beetles in cotton fields during 1965.

Table 10. Percent reduction of nabid bug adults and nymphs in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application	Year	Cotton Fields: Above Caprock	Cotton Fields: Below Caprock	Non-cultivated Area: Above Caprock	Non-cultivated Area: Below Caprock
1	1964	57 x	0	54	+
	1965	51 xx	89 xx	+	44
2	1964	91 x	+	93	+
	1965	95 x	+	+	+
3	1964	---	---	---	---
	1965	95 x	87 xx	85	+
4	1964	45	+	79	+
	1965	80 xx	+ x	43	+
5	1964	---	---	---	---
	1965	45	+ xx	59	+
6	1964	---	---	---	---
	1965	92	0	83	45
7	1964	---	---	---	---
	1965	+	+	41	71

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

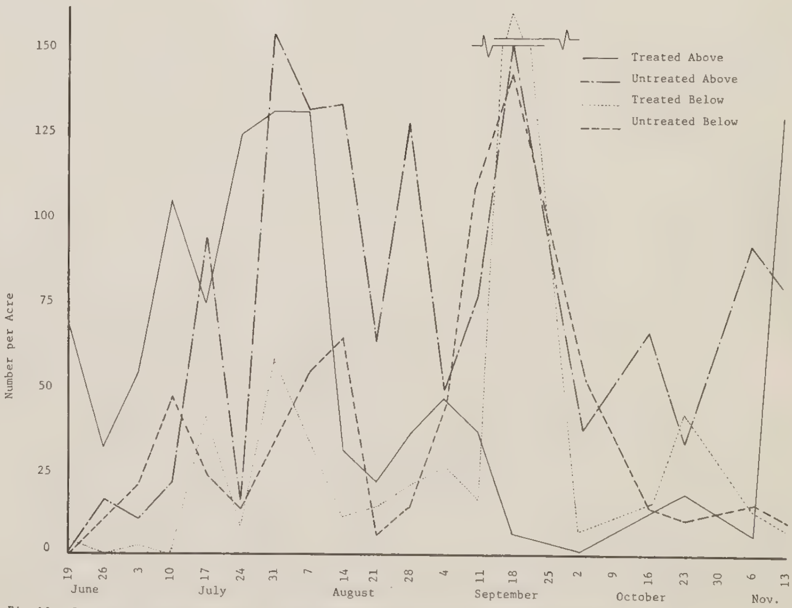

Fig. 10. Seasonal population trends of nabid nymphs and adults in cotton fields during 1965.

Table 11. Percent reduction of assassin bug adults and nymphs in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields		Non-cultivated Area	
		Above Caprock	Below Caprock	Above Caprock	Below Caprock
1	1964	93 xx	50	67	0
	1965	+	+	+	100
2	1964	44	+	+	95
	1965	100	+	+	*
3	1964	---	---	---	---
	1965	100	*	81	*
4	1964	100	100 xx	50	100
	1965	100 xx	100	+	+
5	1964	---	---	---	---
	1965	100	100	+	*
6	1964	---	---	---	---
	1965	100	*	100	*
7	1964	---	---	---	---
	1965	*	*	+	*

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

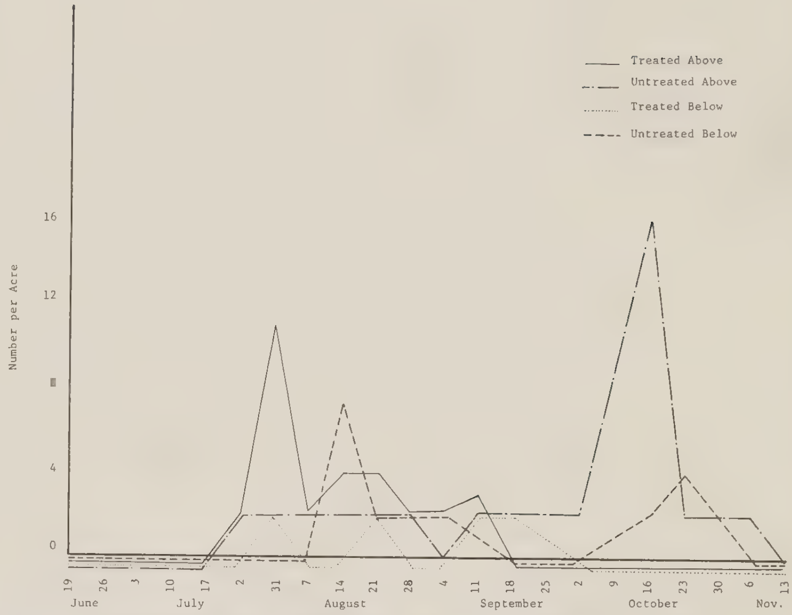

Fig. 11. Seasonal population trends of assassin bugs, nymphs and adults in cotton fields during 1965.

Table 12. Percent reduction of ichneumon wasp adults in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields		Non-cultivated Areas	
		Above Caprock	Below Caprock	Above Caprock	Below Caprock
1	1964	---	---	---	---
	1965	94 xx	100 xx	38	100
2	1964	---	---	---	---
	1965	100	50	6	100
3	1964	---	---	---	---
	1965	100	100	96	56
4	1964	---	---	---	---
	1965	100 x	100	57	+
5	1964	---	---	---	---
	1965	36	100	87	100
6	1964	---	---	---	---
	1965	100	100	100	100
7	1964	---	---	---	---
	1965	100	100	100	*

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

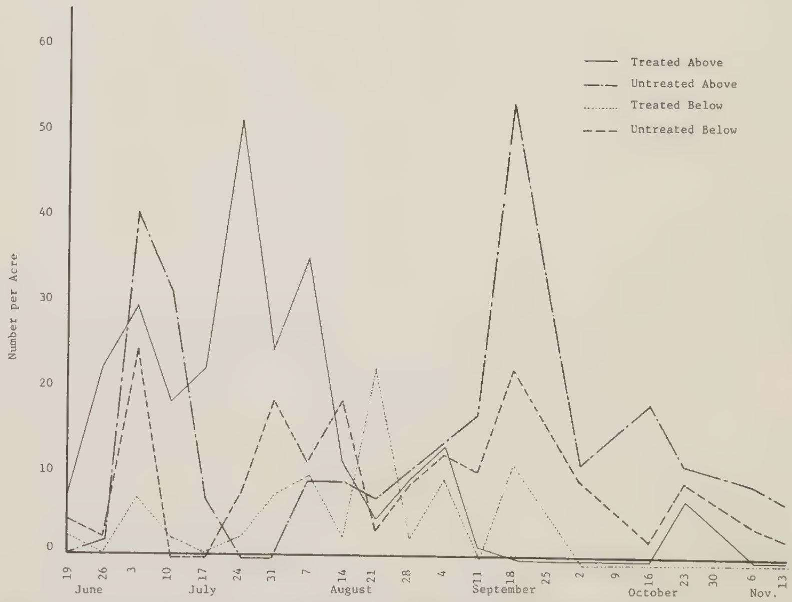

Fig. 12. Seasonal population trends of ichneumon adults in cotton fields during 1965.

Table 13. Percent reduction of syrphid fly adults in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields Above Caprock	Cotton Fields Below Caprock	Non-cultivated Areas Above Caprock	Non-cultivated Areas Below Caprock
1	1964	---	---	---	---
	1965	100	100	*	*
2	1964	---	---	---	---
	1965	100	*	100	*
3	1964	---	---	---	---
	1965	100 xx	*	71	*
4	1964	---	---	---	---
	1965	*	*	50	*
5	1964	---	---	---	---
	1965	100	*	0	+
6	1964	---	---	---	---
	1965	*	*	100	100
7	1964	---	---	---	---
	1965	*	*	*	*

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

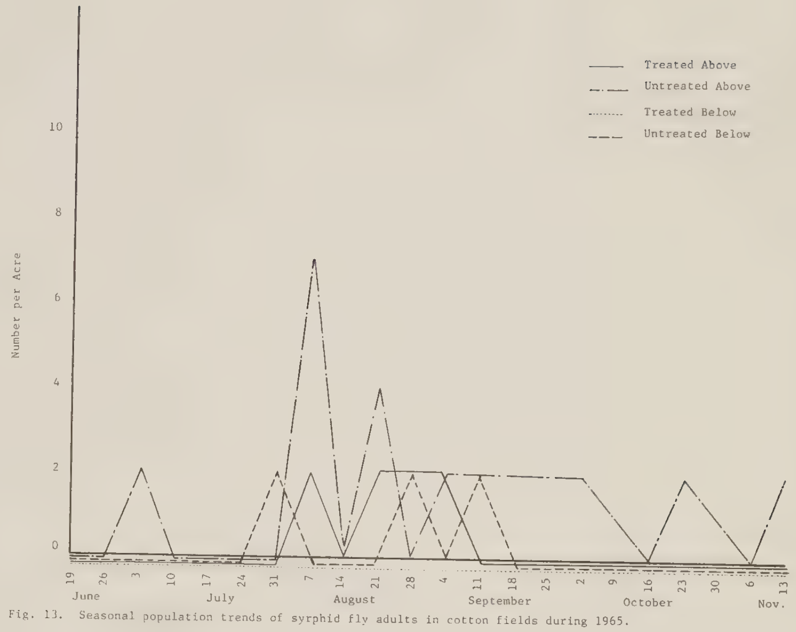

Fig. 13. Seasonal population trends of syrphid fly adults in cotton fields during 1965.

Table 14. Percent reduction of spiders in cotton fields and non-cultivated (unsprayed) areas above and below the caprock in 1964 and 1965.

Application Number	Year	Cotton Fields Above Caprock	Cotton Fields Below Caprock	Non-cultivated Areas Above Caprock	Non-cultivated Areas Below Caprock
1	1964	---	---	---	---
	1965	48	62 xx	+	61
2	1964	---	---	---	---
	1965	74	90 xx	+	86
3	1964	---	---	---	---
	1965	72 x	22	90	+
4	1964	---	---	---	---
	1965	+	+ xx	50	+
5	1964	---	---	---	---
	1965	50	61 x	51	30
6	1964	---	---	---	---
	1965	61	0	49	66
7	1964	---	---	---	---
	1965	74 x	+	29	70

--- not sampled in 1964.
\+ increase in treated as compared with untreated areas.
* none of this group of insects in the samples.
x significant at the 5% level.
xx significant at the 1% level.
a environmental conditions prohibited adequate number of observations for statistical evaluation.

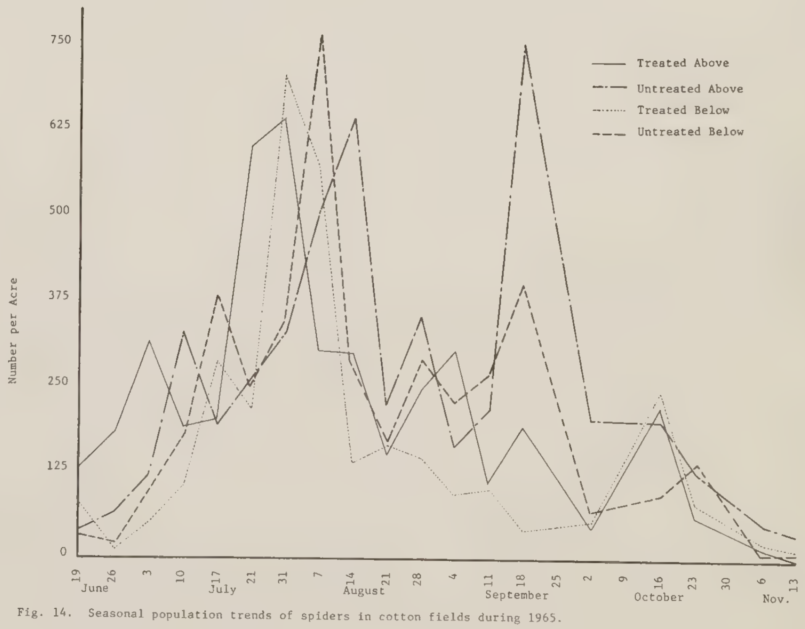

Fig. 14. Seasonal population trends of spiders in cotton fields during 1965.

JOB COMPLETION REPORT

As required by

FEDERAL AID IN FISHERIES RESTORATION ACT

TEXAS

Federal Aid Project No. F-17-R-1

Region I-C Fisheries Studies

Job No. 8 Effects of Aircraft Applications of Malathion on Fish and Aquatic Invertebrates

Project Leader: Paul Fischer, Jr.

J. Weldon Watson
Executive Director
Parks and Wildlife Department
Austin, Texas

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D-J Coordinator

Eugene A. Walker
Director, Wildlife Services

January 24, 1966

ABSTRACT

The United States Department of Agriculture and Plains Cotton Growers Incorporated started an intensive cotton boll weevil control program in North Texas in September of 1964 using several low volume applications of technical malathion at 12 ounces per surface acre of crop land. The program was repeated during the fall of 1965, again using technical malathion, but at the increased application rate of 16 ounces per surface acre on 7 occasions with spacing at 5 to 10 days. This report covers activities which were designed to measure effects of the spray in 2 farm ponds used as study sites. Caged test fish, resident fish populations, bottom sediment organisms, and zooplankton organisms were used to monitor effects of the spray on the environment of test ponds.

Our methods have not demonstrated that malathion has adversely affected aquatic organisms in the study ponds. This study, conducted in the field, is short-term in nature, and is not meant to measure long-term subtle effect of malathion application.

A review of evaluation by other workers investigating malathion use, coupled with observations made during field work for this job, indicate that low volume applications might have merit in control of insect pests with a minimum of damage to aquatic resources. More detailed laboratory studies are needed, however.

SEGMENT COMPLETION REPORT

State of Texas

Name: Region I-C Fisheries Studies

Project No. F-17-R-1

Title: Effects of Aircraft Applications of Malathion on Fish and Aquatic Invertebrates

Job No. 8

Period Covered: March 1965 through October 1965

Introduction:

In September of 1964 the United States Department of Agriculture and Plains Cotton Growers Incorporated initiated an extensive boll weevil control program in the North Texas counties of Briscoe, Floyd, Motley, Dickens, Crosbyton, Garza, and Kent. The treatment area and support area are shown in Figure 1. The Inland Fisheries Function of the Texas Parks and Wildlife Department conducted a short-term pilot investigation to determine the effects of the spraying effort on aquatic life during the first year of the control effort. This report covers evaluation activities during the 1965 spray period. In September, October, and November of 1965, approximately 250,000 acres of cotton were sprayed with technical malathion on 7 occasions at the rate of 16 ounces per acre. The evaluation period is based on the first 4 applications, made 5 to 10 days apart.

Objectives:

General:

To determine the effects, if any, of aircraft applications of malathion on fish and aquatic invertebrates in selected study ponds on the Texas High Plains.

Specific:

(1) To measure the survival rate of largemouth bass and bluegill placed in live-cars in each pond prior to spray applications.

(2) To detect mortality among the resident fish populations of each pond after each application of spray.

(3) To determine numerical changes in invertebrate organisms residing in bottom sediments of each pond.

(4) To determine numerical changes in zooplankton organisms in each pond over the spray period.

Procedures:

Two stable aquatic environments were chosen as study sites. The ponds were man-made basins maintained as stock watering tanks, irrigation reservoirs, and fishing areas. A brief description of the study areas follows.

The McAdoo Site

The study pond near McAdoo, Texas, is about one-half acre in size, with most water depths constant at 3 feet over a smooth bottom. The pond is directly bordering a large cotton field and is surrounded by only sparse vegetative growth. Sago pondweed (Potamogetion pectinatus) is abundant in about one-half of the pond. This pond supports a resident fish population of largemouth bass, channel catfish, redear sunfish, and red shiner. Water quality data are presented in Table 1. This pond's location and abundant insect life make it an excellent study site. Figure 1 shows the approximate location of this study site.

The Quitaque Site

The study pond located near Quitaque, Texas, is a circular one-third-acre pond bounded along most of its circumference by cotton. The pond water is relatively clear and is generally pumped from deep water wells in the area. Shallow shore areas drop quickly off to a depth of about 15 feet. Muskgrass (Chara sp.) occurs over much of the bottom, making bottom sediment sampling somewhat difficult. Water quality data are presented in Table 1. Largemouth bass, plains killifish, and red shiner are resident in the pond. Figure 1 shows the approximate location of this study site.

Every effort was made at both sites to provide spray coverage over the ponds as though they were plots of cotton; however, on several occasions wind velocity was responsible for less than normal coverage. A subjective evaluation of spray coverage as determined from dye card placement is presented in Table 2.

The spray area is one of sparse rainfall and has no permanent natural lakes and very few other lakes suitable for use in this study. Playas are abundant, but they are dry except during periods of rainfall and do not develop a permanent aquatic biomass. Ponds which could be kept at a relatively stable water volume were necessary for this study. This made it necessary to choose ponds with owners who were willing to keep the water level stable with well water. The relative rarity of sites meeting our requirements, and the extreme individuality of ponds in the area made the selection of control ponds impractical. The treatment area above the caprock is almost completely cultivated in the production of cotton and grain crops, while that below the caprock is mixed farmland and pasture.

Sampling frequency and test animal placement during the spray evaluation were designed in consideration of the fact that malathion breaks down rapidly after its application. 1/ 2/

1/ Roberts, J. D., Chishols, R. D. and Koblitsky, L. "Persistence of Insecticides in Soil and Their Effects on Cotton in Georgia". Journal of Economic Entomology, 55:153, (1962).

2/ Mulla, M. S., and Axelrod, H. "Effect of Temperature on Rate of Release of Toxicants From Granules and on Breakdown of Certain Insecticides in Water." Mosquito News, 20:178 (1960).

Figure 1. Area Treated With Malathion and the Approximate Locations of the Study Sites.

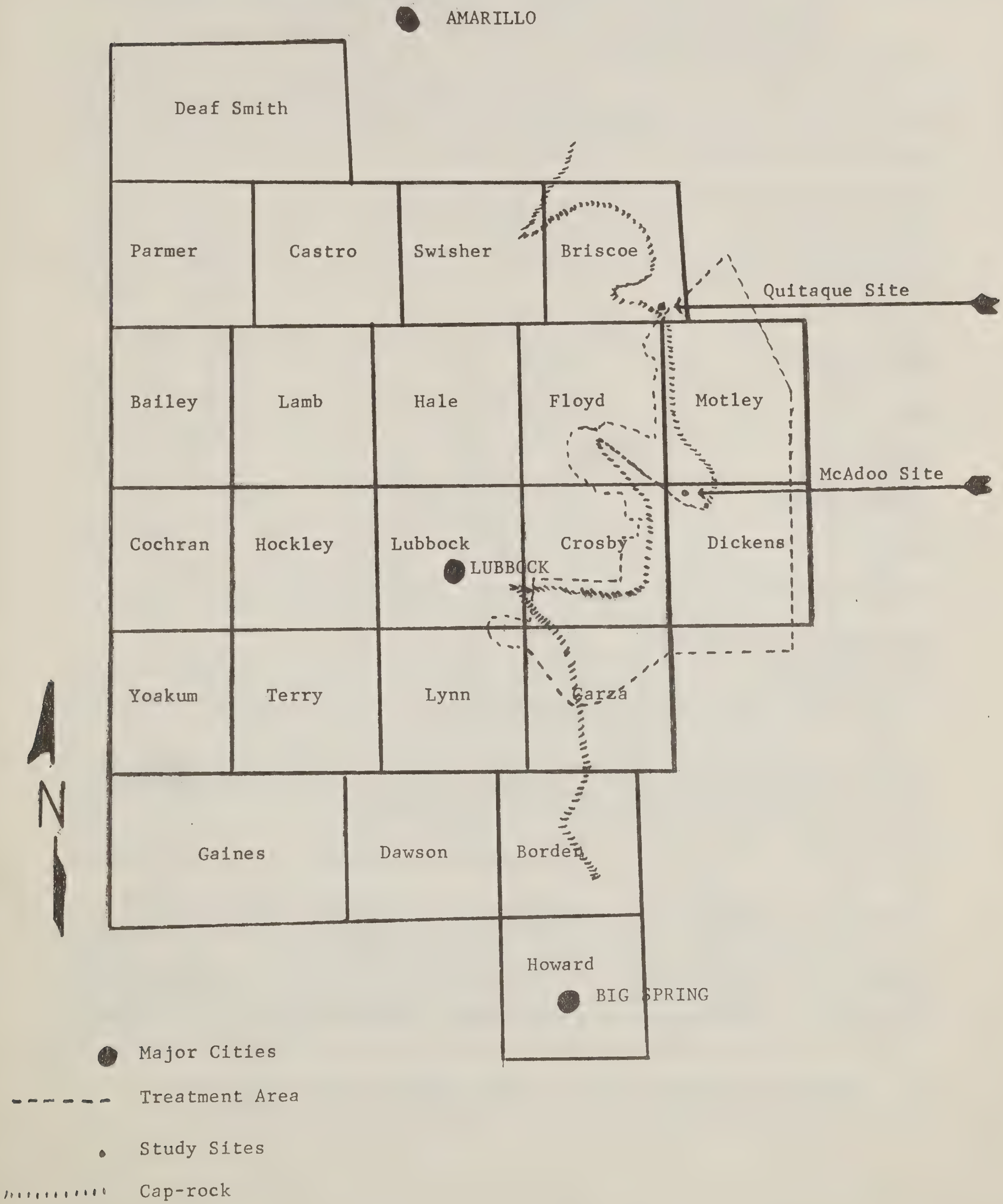

Table 1. Water Quality Data as Determined by the Texas State Health Department. Samples were Collected on September 10, 1965. Results are Expressed as Parts Per Million, With the Exception of the First Two Determinations.

Specific Determination	McAdoo Site	Quitaque Site
pH	9.25	7.45
Conductivity, Micromhos	585	2337
Dissolved solids	351	1202
Total solids	10	10
Chlorides	59	260
Sulfates	44	433
Ammonia nitrogen	0.2	0.2
Nitrite nitrogen	.17	.22
Nitrate nitrogen	0.4	4.65
Phenolphthalein alkalinity	22	0
Total alkalinity	186	207

Table 2. Study Pond Site, Spraying Applications at 16 Ounces of Technical Malthion Per Acre, Date of Each Spray Application, and a Subjective Evaluation of Spray Drift Using Dye Cards.

Study Site	Application 1	Application 2	Application 3	Application 4
McAdoo	9-11-65 (Dr)	9-16-65 (Dr)	9-21-65 (Dr)	9-29-65 (Dr)
Quitaque	9-8-65 (D)	9-14-65 (Dr)	9-27-65 (Dr)	10-2-65 (Dr)

(D) Wind action causing drift of some spray away from study pond.
(Dr) Direct spray contact with little influence by wind action.

The following procedures were used to accomplish objectives set forth in the first part of this report:

(1) The survival rate of largemouth bass and bluegill was measured by placing 2 bass and 10 bluegill in live-cars 2 days before each malathion application and keeping them there 2 days after the application. Observations were then made for abnormal conditions and mortality. A total of 4 bass and 20 bluegill were exposed to each spray treatment. Bluegill used were 2 to 4 inches in length and bass were 4 to 6 inches in length.

(2) Mortality in the resident fish populations was determined by observation. During visits to each spray study pond over the insecticide application period, careful checks were made to detect sick or dead resident fish. A seine was used to drag the bottom of the ponds on several occasions in an effort to detect dead fish.

(3) The status of invertebrate fauna residing in bottom sediments was determined through sampling which was initiated in March 1965, and conducted once each month until malathion applications were started in September. After this time, 4 sets of bottom sediment samples were collected, one set at each study site after each of the first 4 applications of insecticide. Four samples were taken with an Ekman style dredge, 9-inch by 9-inch size, during each visit to the ponds. Sampling was conducted using a grid system to assure randomness in the selection of collection points. Samples were washed separately in the field through number 60-mesh wire screen, bottled, and preserved. In the laboratory, organisms in each sample were identified and counted. Unicellular algae, bacteria, annelids, aquatic beetles, and aquatic mites were not considered because of the difficulty of numerical evaluation caused by the relative scarcity of these organisms.

(4) Sampling to determine numerical trends in zooplankton populations was conducted at the same time bottom sediment samples were taken--once each month starting in March 1965, and extending through August 1965, and once after each of the first 4 malathion applications. A Wisconsin style plankton net and bucket strainer, fitted with number 20-mesh silk bolting cloth, with an upper canvas duck cone 12 centimeters across the top, was used to make the necessary plankton collections. During visits to the study ponds, seven 10-foot drags were made in such a manner as to assure randomness. A combined tow of 70 feet was made at each visit. The 7 collections were combined, bottled, and preserved in the field.

In the laboratory the sample was diluted to 290 milliliters and mixed thoroughly by violent shaking. A 10-milliliter portion was withdrawn by pipette, and a 1-milliliter portion was released into a standard Sedgewick-Rafter counting cell. All zooplankton organisms were identified and counted. The above procedures were performed 3 times for each composite sample. Counts obtained from the 3 independent 1-milliliter portions constituted the basis for sample comparison.

Findings:

1. Results of Tests with Caged Fish. No large scale mortality was noted among caged bluegill and largemouth bass retained in study ponds over the spray period; however, a few isolated deaths were noted which were attributed to rough handling. Table 3 presents data showing the results of holding caged fish through spray periods. These results are comparable with findings from the 1964 spraying operation.

2. Mortality Among Resident Fish. Both study ponds support good populations of largemouth bass and other game and forage species, and no instance of mortality was seen or reported over the spraying period. Observations around the ponds and sampling by seine have revealed no changes in fish populations in these ponds from August 1964 through October 1965. Largemouth bass, recently stocked in the lakes are doing very well. It is interesting to note that centrarchid fishes and certain cyprinodons are very susceptible to organic phosphorus-type compounds. Centrarchids are present in both ponds and cyprinodons are very abundant in the pond near Quitaque. 1/ 2/

3. Effects of the Spray Treatment on Invertebrates Inhabiting Bottom Sediments. Tables 4 and 5 indicate sample results from the McAdoo and Quitaque study sites. The entry figure for each different organism for each month of sampling is the number of organisms obtained from each of 4 dredge samples. Sample results, from March 1965 through August 1965, represent pre-spray sampling, and samples obtained in September and October are post-spray samples. Organisms used for this evaluation were those which occurred most frequently and in greatest numbers, lending themselves to statistical treatment. Several other groups of organisms were occasionally noticed, but their frequency of occurrence was low, producing a sample of insufficient magnitude to permit a good statistical comparison. These organisms included aquatic mites (Hydrachnidae), beetles (Dytiscidae, Noteridae, Gyrinidae, and Hydraenidae), fishfly nymphs (Neuroptera), and bottom dwelling annelids.

Table 3. Study Site, Spray Application, Number and Species Placed in Livecars Over the Spray Period, and Mortality if Present.

Study Site	Application 1	Application 2	Application 3	Application 4
McAdoo	4 bass 20 bluegill MORTALITY 1 bluegill	2 bass 20 bluegill	2 bass 28 bluegill MORTALITY 2 bluegill	4 bass 26 bluegill
Quitaque	4 bass 20 bluegill	4 bass 20 bluegill	4 bass 20 bluegill MORTALITY 2 bluegill	4 bass 22 bluegill

1/ op. cit.
2/ op. cit.

Table 4. Collection Site, Collection Date, Chosen Aquatic Organisms (all Odonata, and Diptera in nymphal or larval stage), and the Number of the Respective Organism in Each of 4 Bottom Samples Collected on the Date Indicated.

McAdoo Collection	Malacostraca Amphipoda	Ephemeroptera Ephemerellidae	Odonata Libellulidae	Odonata Zygoptera	Diptera	Gastropoda Physidae
3/22/65	0 0 0 0	15 5 11 *	5 4 2 *	6 0 1 *	222 36 171 *	0 0 0 0
4/21/65	0 0 0 1	15 13 9 8	1 3 3 10	0 2 0 1	146 33 63 99	0 0 0 0
5/29/65	0 0 0 0	9 13 19 21	2 1 0 0	2 4 1 0	13 6 0 3	0 0 0 0
6/24/65	0 0 1 0	4 2 2 0	2 0 1 0	0 0 0 0	4 12 11 2	0 5 0 2
7/29/65	0 1 0 0	2 0 6 0	0 1 0 0	1 0 1 0	1 0 1 4	0 0 0 0
8/30/65	0 0 0 1	0 2 0 0	2 0 0 0	1 0 0 0	2 4 7 6	1 0 0 0

The above data show the results of pre-spray sampling.

McAdoo Collection	Malacostraca Amphipoda	Ephemeroptera Ephemerellidae	Odonata Libellulidae	Odonata Zygoptera	Diptera	Gastropoda Physidae
9/14/65	12 3 2 4	0 0 0 0	2 2 0 0	20 30 57 10	14 18 9 9	50 47 23 0
9/20/65	1 1 0 2	0 1 0 0	0 1 0 0	10 6 1 0	9 20 10 0	7 47 2 0
9/27/65	0 8 4 3	0 1 0 0	0 0 0 0	116 0 27 4	20 39 50 74	84 89 106 157
10/4/65	0 3 5 8	0 0 0 0	5 2 3 3	127 80 115 110	0 71 42 0	0 9 95 143
	0 0	0 0	0 0	0 0	82 44	202 0

These data show the results of sampling during 4 applications of technical malathion at 16 ounces per surface acre.

* laboratory accident

Table 5. Collection Site, Collection Date, Chosen Aquatic Organisms (all Odonata, Neuroptera, and Diptera in nymphal or larval stage), and the Number of the Respective Organism in Each of 4 Bottom Samples Collected on the Date Indicated.

Quitaque Collection	Malacostraca Amphipoda	Odonata Libellulidae	Odonata Zygoptera
3/23/65	45 2 8 6	1 0 0 0	0 0 0 0
4/20/65	9 4 2 8	1 1 0 0	0 0 0 0
5/29/65	0 0 0 9	0 0 0 0	0 0 0 0
6/23/65	6 2 24 15	0 3 5 6	0 0 1 0
7/30/65	6 2 6 0	14 3 16 5	1 0 0 0
8/31/65	17 10 4 19	9 1 3 4	1 0 0 0

Diptera	Gastropoda Physidae
2 1 4 2	0 5 5 14
2 1 6 6	11 36 5 37
0 7 5 14	0 10 6 35
128 130 294 230	6 13 75 69
13 13 32 21	98 10 51 10
10 9 32 34	27 13 22 158

The above data show the results of pre-spray sampling.

Quitaque Collection	Malacostraca Amphipoda	Odonata Libellulidae	Odonata Zygoptera
9/15/65	3 8 15 19	1 2 2 14	0 0 0 0
9/21/65	20 12 1 12	13 0 3 6	1 0 0 0
9/28/65	49 30 41 30	1 0 0 5	0 1 0 2
10/5/65	87 21 42 79	16 1 3 6	1 0 0 1

Diptera	Gastropoda Physidae
6 2 4 1	32 24 21 45
84 17 3 21	51 5 10 37
15 20 12 9	61 36 54 150
29 7 10 18	179 31 62 93

These data show the results of sampling during 4 applications of technical malathion at 16 ounces per surface acre.

The student's t-distribution z (small sample methods) was used in an effort to detect any statistically significant differences existing between the means of samples collected during the months prior to spraying and during the first four spray applications. 3/ 4/ The following discussion will concern the McAdoo study site.

Table 6. Aquatic Organisms, Degrees of Freedom (d.f.), the Appropriate t-Distribution Value at .05, a t-Value Calculated From Sample Results, and Necessary Interpretations From Data Collected at the McAdoo Study Site.

Aquatic Organisms (McAdoo Site)	d.f.	t at .05	Calculated t-Value	Necessary Interpretation
Amphipoda	39	± 2.022	+4.81	post-spray weighted
Ephemeroptera	39	± 2.022	+4.22	pre-spray emergence
Odonata (Libellulidae)	39	± 2.022	+0.72	
Odonata (Zygoptera)	39	± 2.022	-5.24	post-spray weighted
Diptera	39	± 2.022	+0.21	
Gastropoda (Physidae)	40	± 2.021	-5.73	post-spray weighted

Calculated t-distribution values for Amphipoda, Ephemeroptera, Zygoptera, and Gastropoda indicate significant differences in the means of pre-spray sample counts and post-spray sample counts; however, all groups except Ephemeroptera were very evidently post-spray weighted. The decrease of Ephemeroptera was caused by a large-scale emergence of winged forms from the nymphal stage. This negates any relationship between malathion application and nymphal reduction. Gastropoda (Physidae) showed significant number increases through the spray period. This occurred because of the presence of large numbers of small snails representing recent reproductive activities. This trend was detected during the 1964 study period, and it might appear that September is the period during which snail egg development reaches a peak in this area of Texas. The increases in Amphipoda and Zygoptera were also largely due to new individuals. Mating of mature Zygoptera seemed to reach a peak during the spray period. At this application rate of 16 ounces per surface acre, nymphs are seemingly not harmed, but some adults were killed as malathion spray settled over ponds where large flights were congregated.

This section will present the results of bottom sediment sampling at the Quitaque study site.

3/ Alder, Henry L., and Roessler, Edward B. Introduction to Probability and Statistics. W. H. Freeman and Company, 1964, pp. 123-132.

4/ Li, Jerome C. R., Introduction to Statistical Inference. Edwards Brothers, Inc., Ann Arbor, Michigan, 1961, pp. 119-130.

Table 7. Aquatic Organisms, Degrees of Freedom (d.f.), the Appropriate t-Distribution Value at .05, a t-Value Calculated From Sample Results, and Necessary Interpretations at the Quitaque Study Site.

Aquatic Organism 5/ Quitaque Site	d.f.	t at .05	Calculated t-Value	Necessary Interpretation
Amphipoda	38	-2.025	-3.64	post-spray weighted
Odonata (Libellulidae)	38	-2.025	-1.79	
Odonata (Zygoptera)	38	-2.025	-1.01	
Neuroptera (Sialodea)	38	-2.025	+0.78	
Diptera	38	-2.025	+1.50	
Gastropoda (Physidae)	38	-2.025	-1.91	

5/ Ward, Henry Baldwin, and Whipple, George Chandler, Freshwater Biology. John Wiley and Sons, Inc., 1963.

All calculated t-values except that for Amphipoda are insignificant at the .05 level which can be interpretated to indicate no large differences in pre-spray and post-spray samples through the use of our collection and analysis methods. The significance detected in Amphipoda was due to the larger number of organisms present in post-spray samples. These Amphipoda were small in size, apparently new individuals.

Our methods have detected no detrimental effects on bottom sediment organisms due to malathion applications.

4. Effects of the Spray Treatment on Zooplankton Organisms. The student's t-distribution (small sample methods) was used to test the difference between means of pre-spray and post-spray zooplankton collections. Collections from the study sites are discussed below with Table 8 showing collection data from the McAdoo study site and Table 9 showing collection data from the Quitaque study site.

Table 8. Collection Site, Collection Data, Zooplankton Organisms, and the Numbers of Each Organism Obtained From 3 Individual 1-Milliter Portions of Each Sample (standard 290 milliliter liquid volume for all samples).

McAdoo Collection	Rotifera	Crustacea Cladocera	Crustacea Ostracoda	Crustacea Copepoda	Larval Copepoda
3/22/65	434 378 461	2 0 2	0 0 0	9 6 9	9 12 8
5/05/65	101 130 129	246 306 318	0 0 0	51 56 86	41 60 60
5/27/65	28 28 30	1,044 870 794	0 0 0	66 51 44	34 36 45
6/23/65	98 96 118	137 113 131	0 0 0	269 206 242	222 214 226
7/29/65	5 6 7	0 1 1	0 0 0	5 10 13	106 117 107
8/30/65	21 15 9	1 0 1	0 1 0	0 0 1	13 21 17

The above data shows results of pre-spray sampling.

9/14/65	47 49 61	28 16 22	21 17 29	10 4 3	0 0 0
9/20/65	165 140 160	18 12 20	0 0 0	6 6 8	4 6 3
9/27/65	338 380 418	1 3 3	0 0 0	8 2 4	14 16 12
10/4/65	657 598 774	4 4 10	0 0 0	2 6 3	10 5 7

These data show the results of sampling during 4 applications of technical malathion at 16 ounces per surface acre.

Table 9. Collection Site, Collection Data, Zooplankton Organisms, and the Numbers of Each Organism Obtained From 3 Individual 1-Milliliter Portions of Each Sample (standard 290 milliliter liquid volume for all samples).

Quitaque Collection	Rotifera			Crustacea Cladocera			Crustacea Copepoda			Larval Copepoda		
3/23/65	11	8	7	0	0	0	0	0	0	0	0	0
5/06/65	79	109	95	0	0	0	0	0	0	2	0	2
5/28/65	53	40	53	1	4	2	2	2	1	5	3	2
6/24/65	83	85	69	0	0	1	1	2	0	3	2	2
7/30/65	192	126	160	0	2	1	0	0	0	0	0	0
8/31/65	211	234	244	1	2	0	0	1	1	0	1	0
The above data show results of pre-spray sampling.												
9/15/65	97	113	112	0	0	0	0	0	0	0	1	1
9/21/65	112	130	144	0	0	0	0	1	0	2	4	2
9/28/65	124	183	146	0	0	0	0	0	0	1	0	0
10/5/65	233	265	249	0	0	0	1	0	0	2	4	2

These data show the results of sampling during 4 applications of technical malathion at 16 ounces per surface acre.

Table 10. Aquatic Organisms Collected From the McAdoo Site, Showing Degrees of Freedom (d.f.), the Appropriate t-Distribution Value at .05, a t-Value Calculated From Samples Results, and Necessary Interpretations.

Aquatic Organism	d.f.	t at .05	Calculated t-Value	Necessary Interpretation
Rotifera	28	± 2.048	-2.71	post-spray weighted
Crustacea (Cladocera)	28	± 2.048	+2.14	heavy spring build-up
Crustacea (Ostracoda)	28	± 2.048	-2.26	heavy spring build-up
Crustacea (Copepoda)	28	± 2.048	+2.29	post-spray weighted
Larval Copepoda	28	± 2.048	+3.13	heavy spring build-up

The differences in means of pre-spray and post-spray samples are not due to malathion application, but to post-spray weighting in Rotifera and Ostracoda, and to heavy spring build-ups of Copepoda, Cladocera, and larval forms of Copepoda due to reproductive activities.

Table 11. Aquatic Organisms Collected From the Quitaque Site Showing Degrees of Freedom (d.f.), the Appropriate t-Distribution Value at .05, a t-Value Calculated From Sample Results, and Necessary Interpretations.

Aquatic Organism	d.f.	t at .05	Calculated t-Value	Necessary Interpretation
Rotifera	28	±2.048	-2.14	post-spray weighted
Crustacea (Cladocera)	28	±2.048	+2.44	heavy spring build-up
Crustacea (Copepoda)	28	±2.048	-1.63	
Larval Copepoda	28	±2.048	- .67	

Differences in means of pre-spray and post-spray samples are not interpretated as being due to malathion application. In Rotifera, a great increase was noted during the spray applications, and in Cladocera a heavy spring build-up was evident. These increases were due in both instances to reproductive activities.

Our short-term field investigations have not shown that malathion has influenced zooplankton populations in either study pond.

Summary and Conclusions:

We have been unable to show adverse effects on (1) caged largemouth bass and bluegill, (2) resident populations of largemouth bass, bluegill, channel catfish, and various "forage" fish, (3) zooplankton populations, and (4) bottom sediment fauna from the application of 16 ounces of technical malathion per surface acre.

Field investigations of this type must necessarily be limited in scope and general in nature, with studies designed to investigate long-term effects conducted in the laboratory where controlled conditions are available. Means and methods are not available to demonstrate long-term subtle effects of malathion application on aquatic life, and probably, statistically significant effects could be demonstrated only in cases where great damage has been done to the environment.

Conditions under which our study was conducted are somewhat special in that the area is primarily arid with very few lakes or ponds and no permanent streams. The application of malathion at 16 ounces of technical material per surface acre to marsh or swamp might possibly result in mortality to aquatic life because of the lack of sufficient dilution of the insecticide. Mosquito and gnat control is important in many areas of our country. Tentatively, our field observations and other work indicate that malathion in low volume doses might have application in the control of insect pests with little harm to aquatic resources. By observations made around margins of the study ponds, some mortality was noted among winged forms (Diptera, Ephemeroptera, Odonata) as malathion spray settled on flights of these insects. Continued and extensive use of malathion might reduce the numbers of aquatic forms of these organisms indirectly by a reduction of the adult populations. Certainly, malathion is much safer than most insecticides due to its low mammalian toxicity, relatively rapid breakdown rate, and lack of toxic residues which characterize chlorinated hydrocarbon insecticides. Recent investigations by the United States Fish and Wildlife Service report no significant mortality to wildlife or aquatic life at application rates of up to 1.5 pounds per surface acre. 6/

In view of the nationwide alarm with regard to the use of long-lived compounds, malathion seems to have merit and its use should be expanded along with evaluations of its effects on the environments exposed.

Acknowledgements:

Credit is given to Project F-17-R-1 Biology Technicians Ronald Meletti and Monte Gardner for their assistance in the field, laboratory, and office with regard to this work.

6/ United States Department of the Interior, Fish and Wildlife Service. Pesticide-Wildlife Studies, 1963, A Review of Fish and Wildlife Service Investigations During the Calendar Year, Circular 199.

Prepared by Paul Fischer, Jr.

Approved by Marion Toole
Coordinator

Date January 24, 1966

Leo D. Lewis
Inland Fisheries Supervisor

APPENDIX A

Common and Scientific Names of Fish Mentioned in This Report

Common Name	Scientific Name
Red shiner	*Notropis lutrensis* (Baird and Girard)
Fathead minnow	*Pimephales promelas* (Rafinesque)
Channel catfish	*Ictalurus punctatus* (Rafinesque)
Plains killifish	*Fundulus kansae* (Garman)
Bluegill	*Lepomis macrochirus* (Rafinesque)
Redear sunfish	*Lepomis microlophus* (Gunther)
Largemouth bass	*Micropterus salmoides* (Lacepede)

APPENDIX B

Taxonomy of Invertebrates Mentioned in This Report 5/

- Phylum-Rotifera
- Phylum-Annelida
  - Class-Hirudinea
- Phylum-Arthropoda
  - Class-Crustacea
    - Subclass-Branchiopoda
      - Order-Cladocera
    - Subclass-Ostracoda
    - Subclass-Copepoda
    - Subclass-Malacostraca
      - Order-Amphipoda
  - Class-Insecta
    - Order-Ephemeroptera
      - Family-Ephemerellidae
    - Order-Odonata
      - Suborder-Anisoptera
        - Family-Libellulidae
      - Suborder-Zygoptera
    - Order-Neuroptera
    - Order-Diptera
    - Order-Coleoptera
      - Family-Noteridae
      - Family-Hydraenidae
      - Family-Dytiscidae
      - Family-Gyrinidae
  - Class-Arachnida
    - Order-Acrina
      - Suborder-Trombidiformes
        - Family-Hydrachnidae
- Phylum-Mollusca
  - Class-Gastropoda
    - Family-Physidae

5/ Ward, Henry Baldwin, and Whipple, George Chandler. Freshwater Biology, John Wiley and Sons, Inc., 1963.

Taxonomy of Invertebrates

Phylum-Rotifera
Phylum-Annelida
    Class-Hirudinea
Phylum-Arthropoda
    Class-Crustacea
        Subclass-Branchiopoda
            Order-Cladocera
        Subclass-Ostracoda
        Subclass-Copepoda
        Subclass-Malacostraca
            Order-Amphipoda
    Class-Insecta
        Order-Ephemeroptera

        Order-Odonata
            Suborder-Anisoptera

            Suborder-Zygoptera
        Order-Neuroptera
        Order-Diptera
        Order-Coleoptera

    Class-Arachnida
        Order-Acarina
            Sub-order-[illegible]

Phylum-Mollusca
    Class-Gastropoda

1/ Ward, Henry Baldwin, and [illegible]
John Wiley and Sons, Inc., [illegible]

JOB COMPLETION REPORT

As required by

FEDERAL AID IN WILDLIFE RESTORATION ACT

TEXAS

Federal Aid Project No. W-88-R-5

Dynamics of Bobwhite Quail In The West Texas Rolling Plains

Job No. 7 Effects On Quail, Migratory Birds, And Non-game Birds, Of Aerial Applications of Malathion

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February 3, 1966

ABSTRACT

Approximately 200,000 acres of cotton in several Panhandle counties were treated for boll weevil control during the fall months of 1965. Aerial applications of malathion were made at the rate of 16 ounces of pure malathion per acre at intervals of approximately 7 days. Native bobwhites residing in marginal cover and frequenting cotton fields, were studied repeatedly from September into November when the spray operation was stopped. Captive bobwhites were exposed to contact with malathion by placing them in open cages in the path of spray planes. They were fed commercial game feed which had been exposed to malathion spray in the same manner.

Findings were negative as far as the sprayed rate was concerned. Birds exposed to heavier concentrations of malathion died in a very short time.

It was found that many more extremely toxic insecticides were being used, on a private basis, in the project area. In one case a landowner lost approximately 25 head of sheep. This loss was apparently caused by toxic insecticides contaminating the water used by the animals.

It is recommended that this study be expanded to allow investigations of the kinds of insecticides in use, the extent of their use, and whether residues are being built up in wildlife occupying field margin habitats.

JOB COMPLETION REPORT

State of Texas

Project No. W-88-R-5

Job No. 7

Name: Dynamics of Bobwhite Quail in the West Texas Rolling Plains

Title: Effects on Quail, Migratory Birds, and Non-Game Birds, of Aerial Application of Malathion

Period Covered: September 1, 1965 - December 31, 1965

Progress Status: Second Year of a 3-Year Study

Objectives:

(a) To determine effects of malathion sprayed at the rate of 16 fluid ounces of pure material per acre on quail through direct contact.

(b) To determine mortality resulting from spraying malathion on foods and water of quail, waterfowl, mourning doves, and shorebirds.

(c) To determine changes in populations on the above classes of birds which might reasonably be attributed to use of malathion and record rate of population recovery.

(d) To record mortality and rate of recovery for insect orders and species which food habits study, during previous project segments, has shown comprise significant percentages of quail foods during early fall.

Procedures:

(a) Expose 10 captive bobwhites to direct contact with aerial spray applications of malathion by setting cages in field borders prior to spraying operations. At other times care for birds in already prepared facilities, and compare mortality with that of an equal number of bobwhites in a control group.

(b) Select 3 study areas, respectively in Motley, Dickens, and Floyd Counties. The study areas in each case to consist of cotton fields which will be sprayed with malathion at 10-day intervals, beginning September 1 and continuing until frost. These areas will be selected with the following requirements and shall be representative of the following habitat types: shelterbelt margins (Motley County), shinoak-sagebrush margins (Dickens County), and mesquite-sagebrush margins (Garza County). Each margin to contain quail coveys as determined by census before applications of malathion. Select at least one playa lake with water and affording habitat for waterfowl and shorebirds.

Search all habitat at field borders following each aerial application of malathion for dead, sick, or distressed birds. Collect obviously sick birds. Search margins of playa lakes for evidence of mortality among doves, waterfowl and shorebirds. Quick-freeze all specimens for analysis.

(c) Make covey counts in all quail habitat at field borders before each aerial application of malathion. Do call and sight counts of other birds, make sight counts of all waterfowl and shorebirds using playa lake before applications. Repeat counts in interim between applications. Use trained bird dogs as soon as weather permits.

(d) Record population changes in families and order of insects which have been shown by studies to be important late summer foods of quail. In this activity, Dr. Donald Ashdown of Texas Technological College of Lubbock will cooperate to the extent of providing population data and identification of insects.

Results:

(a) Exposure of Bobwhites to Malathion Spray - Before the spraying program began in early September, a total of 38 wild birds was live-trapped to provide specimens to be subjected to aerial spraying. From this number, 12 adults and 12 juveniles were selected for the experiment. Ten birds were used as the "spray birds" and the remaining were held as control birds.

Both groups were kept in identical housing and were cared for in the same manner. Caution was taken to provide adequate protection against adverse weather; however, the birds were kept outside in order to assimilate as near natural conditions as possible. Food and water were kept before both groups at all times.

As last year, a commercial game bird feed was used for both groups. Sufficient amounts of the feed were carried on each "spray intercept" to provide the "spray birds" with plenty of food during the intervals between sprayings.

Table 1 contains the spray schedule as set by the controlling organization along with those dates when the birds were sprayed and the check dates. Plans were made to observe a 5 to 7 day interval between sprayings; however, weather again this year made the schedule somewhat erratic. Even with this erratic schedule sufficient timing prevailed to permit this part of the work to progress satisfactorily.

The "spray birds" were carried to the field in two 24- by 18- by 6-inch cages. There was an equal number of juveniles and adults in each cage. The spray plane was located and the cages set out far enough ahead of the plane's route to allow the birds to settle. Since skip-row cotton farming was prevalent, the cages were well exposed to the malathion mist. The cages were located approximately 25 yards apart.

Table 1
Spray Schedule and Associated Work Dates

Application	Schedule Dates	Dates Birds Sprayed	Spray Interval	Dates Plots Checked
No. 1	Sept. 1-7	Sept. 10	-	Sept. 2 & 11
No. 2	Sept. 14-21	Sept. 17	7	Sept. 18
No. 3	Sept. 22-29	Sept. 27	10	Sept. 28
No. 4	Oct. 3-11	Oct. 8	11	Oct. 9
No. 5	Oct. 14-28	Oct. 14	6	Oct. 15
No. 6	Oct. 29-Nov. 11	Nov. 5	22 1/	Nov. 6

1/ Adverse weather conditions prevented keeping the proper time interval.

The feed was spread evenly over a white cloth between the two cages to allow good coverage by the malathion mist.

After the birds were sprayed, they were returned to the holding pens on the Matador Wildlife Area for daily observations. Of particular interest was the fact that the sprayed birds retained the characteristic odor of malathion for a day or two after being sprayed. Both groups of birds were kept in the holding pens for approximately 6 weeks after the spray program had terminated. This was done to record any residual effects of the malathion on the sprayed birds.

During the experiment, one adult female died after two applications of malathion. The bird was immediately frozen for later necropsy by qualified personnel at the University of Wisconsin. However, before the bird was shipped, it was learned that malathion dissolves and is broken down in the tissue so quickly that results of tissue examination would be useless. Examination would have to be directly after death had occurred. The bird was later necropsied and from visual estimates there was no noticeable cause of death such as discoloration of organs, edema, etc. Whether she succumbed to malathion is not known. The remaining 9 birds continued through the schedule and were later released.

In comparing the two groups, the sprayed birds experienced a weight loss and maintained a lower average weight throughout the period, although they were easily as active as the control group. This weight loss could have been a result of the rigors of transfer from holding pen to cage and back again in addition to traveling more than 70 miles each round trip. Attempts will be made to answer this question during the next segment since it would be highly important to know whether malathion causes weight loss even though it doesn't kill.

As an element of augmentation of this phase of the project, 6 birds (additional to the 24) were sprayed with malathion using a hand-pump type spray. The spray liquid, 98 per cent pure malathion, was obtained from

one of the spray crews and was the same mixture as that which was used in the spraying program. The birds were placed in a cage and the spray was applied with the spray nozzle held about 15 inches away from the cage. Two sweeps of the hand were made to completely cover the birds but not totally drench them. This took place at 3:30 p.m. and by 8:00 a.m. the next day all 6 birds were dead. All birds were found in a prostrate position with toes extended similar to conditions involving suffocation. Since the birds were not given any feed, ingestion of the malathion was not possible unless it was taken in when the birds attempted to preen themselves.

It was not possible to measure the amount of spray these birds received. The body of each bird was well covered but not soaked. The one determination that was made is that malathion will kill bobwhites if applied in sufficient quantities.

(b) Selection of Study Areas: The same study plots that were used during the last segment were used again this year since previous reporting provided excellent vegetative type-mapping and each plot offered the setting required for this study.

Two additional playa lakes were inspected as a result of reports from landowners of dying livestock and the appearance of dead birds around the shoreline. The results of these inspections will be covered under later headings.

The study plots retained the same numbers as were listed in previous reports. Furthermore, no changes occurred in the physical description of the cotton field plots.

(c) Determination of Avian Mortality: Prior to the initiation of the spray program, two visits were made to each study plot and the two playa lakes to determine the relative abundance of birdlife in residence there. No attempt was made to record all species of birds seen since the spray period overlapped the migration season and combined emigration and immigration would make species numbers irrelevant to mortality estimates. On this site there was adequate brush for cover but very few weed seeds were available. The prominent food species, western ragweed (*Ambrosia psilostachya*), Texas croton (*Croton texensis*), snakeweed (*Amphiachyris dracunculoides*), common sunflower (*Helianthus annuus*) and redroot amaranth (*Amaranthus retroflexus*), which are used by many varieties of birdlife were scarce or absent altogether. Both lakes were dry at this time and had been for most of the summer.

Study Area No. 1, owned by P. M. Cooper, lies 4 miles east of Roaring Springs in Motley County. Sixty of the 160 acres included in the Cooper farm were planted to cotton in 1965. The cotton was in 2 fields separated by a laid-out strip containing several small plots of mesquite thickets, sagebrush, and grasses. The lower of the 2 fields lies in a bottom land situation and was the one selected for intensive study. The west side has a border of dune sand between the field and a farm road, widening to approximately 300 feet at the southwest corner. This waste area is covered with

typical sand dune vegetation. Sagebrush (*Artemesia filifolia*), mesquite (*Prosopis juliflora*), and wild plum (*Prunus angustifolia*) comprise the principal woody cover, and sand dropseed (*Sporobolus cryptandrus*) is the principal grass. Fringeleaf paspalum (*Paspalum ciliatifolium*), an important quail food, is common. Tillage and soil disturbance at the field edge has resulted in hedges of sunflowers (*Helianthus annuus*), intermingled with pigweed (*Amaranthus retroflexus*), croton (*Croton texensis*), and Texas panic (*Panicum texanum*). All sources of quail foods were in locations which were certain to be exposed to malathion.

The border along the south side of the cotton field is equally good quail habitat. About 75 yards wide, it is an ungrazed mixture of dense sagebrush, mesquite shrubs, and thickets of western soapberry (*Sapindus drummondi*). The side against the field edge contained all the sources of quail foods enumerated above and in addition to a great deal of sorghum almum (*Sorghum* sp.) which has escaped from former plantings.

The east side of this field is margined by a strip of worn-out and retired soil 75 to 100 yards in width; behind this is a narrow strip of mesquites and sagebrush separating the 2 cotton fields. It appeared that the coveys resident in these niches of habitat and their food would be sprayed with malathion regardless of the direction of the plane's passage.

Study Area No. 2, owned by Ira Sullivan, is located 1½ miles east of the cotton gin and country store known as East Afton in the northeast quarter of Dickens County. This is in a sandy shinoak area for the most part, but the quail habitat selected for study consists of a narrow L-shaped mesquitebrush pasture of 75 acres, bracketed on the north end by cotton fields on both sides.

At one corner in the pasture fence an offset included an irrigation well and a deep dug pond. The latter was surrounded by cotton on 3 sides.

Study Area No. 3 consists of fields belonging to Ira Sullivan and Coy Morse, and is located approximately 8 miles east of Study Area No. 2. The 2 fields, one containing 67 acres and the other a larger but undetermined acreage, are separated by a shelterbelt planting approximately 2,000 feet in length which held 2 coveys of bobwhites when first surveyed.

The shelterbelt consists of a somewhat ragged stand of desert willow (*Chilopsis linearis*), Osage orange (*Maclura pomifera*), Chinese or Siberian elm (*Ulmus* sp.), white mulberry (*Morus alba*), and common honeylocust (*Gleditsia triacanthos*). The entire east margin of the Sullivan cotton field was bordered with a narrow belt of shinoak, mesquite, and sagebrush.

Lake No. 1 is at the center of a small pasture surrounded by farmland. Its area, at the time when first inspected, was estimated at 15 acres and it was very shallow. A field of irrigated cotton extended to within about 150 yards of the lake and seemed to contain a major portion of the slope or watershed into this lake. Lake No. 1 is located 3 miles northwest of Floydada and 1 mile west of Highway No. 70.

Lake No. 2 lies 6 miles west of Floydada and 2.8 miles north of Farm Road No. 784. This is a small lake, but deeper, a portion of it having been used as a borrow pit for earth with which to elevate the adjacent farm road. When full it would have extended to the margins of 2 cotton fields. At the time when located, the cotton was approximately 100 yards distant from the shore-line.

Neither lake provided any visible source of food for waterfowl. In this respect they are characteristic of most of the playa lakes in the South Plains. They afford only resting areas for waterfowl.

On September 2, the three plots were inspected thoroughly and yielded the following pre-spray inventory:

Perryman Tract - No coveys were flushed from the study plot; however, tracks, dusting sites and fresh roost signs indicated 2 to 3 bobwhite quail (Colinus virginianus) coveys (estimated) were using the area. Other bird-life activity seemed normal for the season.

There were no boll weevils found during the checks made of the cotton plants, and the insect population was quite sparse, probably due to the very dry summer.

Sullivan Tract - The non-cultivated area was checked thoroughly. Two bobwhite coveys (one had 4 birds and the other estimated at 12-15 birds) and one blue quail (Callipepla squamata) covey (number unknown) were found using the area. In the non-cultivated area there was very little food and cover available; however, on the east side of the tract there was a large grain sorghum field offering maize and hybrid haygrazer.

A small water impoundment on this tract showed little sign of aquatic life. A dead turtle was found in the edge of the water. This impoundment is joined on three sides by cotton fields.

Doves (Zenaidura macroura) were quite plentiful in this area as well as meadowlarks (Sturnella neglecta). The songbird population seemed normal for the season.

Cooper Tract - On this tract, two coveys of bobwhite (numbers estimated at 8 to 10 per covey) were located. One covey was toward the mid-point and the other was in the southwest corner of the tract. This population compares with three coveys which were reported last year. Dusting sites, tracks and roost sites indicated heavy usage of the field edges. As a result of this pre-spray inventory being started very early in the morning, two large concentrations of doves were flushed on opposite ends of the mesquite brush pastureland. Two red-tailed hawks (Buteo jamaicensis) were seen perched in one of the larger mesquites. As on the other two tracts, songbird numbers seemed normal for this season of the year.

Playa Lakes No. 1 and 2 - Since the lakes were dry when first checked and had been dry all summer, there was little information gained from the initial pre-spray inventory. Rains did come mid-way during the spray program

and filled both lakes to approximately one third capacity. At this time no waterfowl were present but there were such species as the common snipe (Capella gallinago), long-billed curlew (Numenius americanus), killdeer (Charadrius vociferus) and other more common types of shorebirds which frequent the lakes in the Panhandle.

Discussion:

Information obtained from checks on the study areas made throughout the spray period revealed no recognizable detrimental effect on birdlife. Post-spray inventories showed little change in avian population on the study areas which couldn't be attributed to migration or normal turnover. This finding is made more significant this year since the rate of application was increased from 12 ounces per acre, used last year, to 16 ounces per acre of 98 per cent pure malathion. It was known in advance, however, that malathion was very low on the toxicity scale and that it has a very short residual life. Table 2 shows a comparison of bobwhite populations on the three study plots between the years of 1964 and 1965.

Table 2
Bobwhite Populations - Three Study Plots

	Number of Bobwhite Coveys			
Study Tract	Pre. 1964	Post 1964	Pre. 3/ 1965	Post 4/ 1965
Cooper (No. 1)	3-	3 2/	2	2
Sullivan (No. 2)	5-	1 1/	3 1/	2 1/
Perryman (No. 3)	4-	4 2/	2-3 2/	2

1/ One bluequail covey.
2/ Estimated from usage signs.
3/ Counts made before spraying started.
4/ Counts made after spraying program ended.

The experiment with the 6 birds which were sprayed with a pump-type hand spray does show, however, that malathion in sufficient quantities will kill game birds by contact means. It would seem that the plumage of these birds would provide run-off and a degree of protection that would prevent little body absorption of the malathion. The two remaining possibilities would be the ingestion of the liquid from preening efforts to dry themselves or by inhalation of the fumes. The lack of proper laboratory facilities and training to make histological studies of the lungs, epidermis, eyes and other areas of absorption prevents pursuing this aspect further.

It is evident that ingestion of contaminated feed at the 16 ounce per acre level will not prove fatal. Next year's work will be designed to determine whether the contaminated feed caused the loss of weight in the sprayed birds or if it was the rigors of transportation.

During the course of the investigation, the numbers of insects present on the study plots were so low that no information could be gathered on the effects of the spray on the population.

Inspection of the playa lakes following the end of the spray period indicated little effect. Numbers of birds using the lake edges had actually increased as the permenancy of the water level extended. On lake No. 1, 87 waterfowl were counted on the December 6 visit. Two dead ducks, a drake blue-winged teal (Anas discors) and a hen gadwall (Anas strepera) were recovered along the shoreline. These were victims of prior hunting. The remains of a dove was found near the water line but it was so decomposed that the cause of death could not be determined. No other evidence of avian mortality was found.

Regarding the effects of aerial spray on playa lake wildlife, reported here is the findings of an inspection of one additional lake. This inspection was made in response to calls from landowners. This lake is located 6 miles due west of Doughtery in Floyd County. This lake is within the spray zone which is composed of 4,000 square miles above and below the caprock which is outlined by the USDA as a barrier to advancement of the boll weevil to the High Plains. The call from landowners came as a result of sheep dying from drinking the water in the lake. A total of 20 sheep died shortly after they were turned in on the pasture surrounding the lake. The landowner then moved the sheep to a nearby pasture without further losses. However, two weeks later when water in the second pasture ran out, the landowner hauled water from the lake in question and another 5 sheep died. Although various other types of insecticides were used in this area in addition to malathion, this one case clearly points up the need to thoroughly investigate the apparently uninhibited use of deadly chemicals which pose a threat not only to wildlife but to humans as well. It seems completely futile and a waste of time and money to attempt to evaluate the effects of malathion on wildlife when the use of far more deadly chemicals such as methyl parathion, Endrin, Aldrin and DDT are used in the same areas.

To further underline the need for thorough investigations of the insecticide problem and further pronounce the reservation affixed to any statement of negative results reported in the work, the following example is given. When the "spray birds" were carried to Motley County for the third spraying, a field located southeast of Roaring Springs was used. After the spray plane had passed and before the birds were picked up, the landowner came along and the author inquired about previous spray treatments on the field. The landowner stated that prior to the beginning of the spray program, he applied a mixture of methyl parathion, Endrin and DDT on the same field at the rate of one (1) gallon per acre.[1/] This compares with the 16 ounces per acre of far less lethal malathion used in the spray program. The landowner said that between the first and second applications of malathion

1/ The various pesticide agents were applied by aerial application.

he applied a second aerial treatment of the same mixture on the same field. This application was directed primarily at the pink bollworm. He also said that distributors of the chemical mixture advised that no humans enter the field for three days after treatment. It is more than obvious that had the study plots received the same degree of treatment, post-inventories would have been drastically altered.

To reiterate, ver batum, the recommendations of the previous report, it is recommended that this study be expanded to allow investigations of the kinds of insecticides in use, the extent of their use, and whether residues are being built up in wildlife occupying field margin habitats. To continue this study with malathion as the chemical adversary merely camouflages the real potential significance of more expanded and intensive investigations.

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